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Synthetic Futures and Competition Law: Towards the Emergence of Precautionary Principle-Minded Approaches

Ioannis Lianos[*]

The study presents an in-depth analysis of the challenges faced by competition law enforcement in light of the rapid advancements in AI, quantum computing, and synthetic biology. It delves into the various approaches that competition law institutions, such as competition agencies and courts, can adopt to address the uncertainties surrounding the competition impact of corporate strategies and conduct in developing and applying these new General Purpose Technologies. The study focuses on the four key features of this "coming wave": asymmetry, hyper-evolution, omni-use, and autonomy, all interconnected with the rise of complex systems that contribute to uncertainty. It explores the limitations of the Ordinary Risk Management (ORM) approach typically followed in competition law, based on the expected utility framework in such situations. The study advocates for the application of the precautionary principle as a more accurate description of the approach taken by competition authorities in this context and a more normatively adequate option for regulating threats of harm in complex systems and integrating responsible innovation concerns. Moreover, the study extensively examines how the precautionary principle can be seamlessly integrated into the design of competition law institutions and the substance of competition law, discussing the various containment tools used by competition authorities to address uncertainty.

INTRODUCTION

The rise of new technologies has always been a challenge for competition law enforcement, starting with the expansion of railways,[1] the development of mobile and wireless telecom networks, the growth of digital online platforms, and most recently the evolution of Artificial Intelligence 'AI'. As the fourth industrial revolution unveils, fusing the physical, digital and

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[1] *See* US v. Terminal Railroad Association, 224 U.S. 383 (1912); Frank Dobbin & Timothy J. Dowd, *The Market that Antitrust Built: Public Policy, Private Coercion, and Railroad Acquisitions, 1825-1922*, 65(2) AM. SOCIOL. REV. 631 (2000); Richard White, *For tech giants, a cautionary tale from 19th century railroads on the limits of competition,* THE CONVERSATION (March 6, 2018), https://theconversation.com/for-tech-giants-a-cautionary-tale-from-19th-century-railroads-on-the-limits-of-competition-91616.

biological worlds,[2] we are witnessing unparalleled changes in our economic, social and political systems propelled by generative AI and Large Language Models (LLMs), gene-editing and synthetic biology, robotic automation, and quantum computing.[3] This technological (r)evolution gives rise to the emergence of artificial phenomena that are in the interim assessed according to the traditional scientific and disciplinary framework(s) developed to engage with the natural world.[4] However, this wave of technological developments are expected to lead to the emergence of "synthetic" systems and worlds in which humans may not be at the driving seat, raising (for some) the distressing potentiality of a "life post-anthropocene."[5] There are four central features of this "coming wave"[6] of interest for our study:

(a) it gives rise to significant asymmetries of power, as these new technologies have the potential to establish modern "empires" that will be quite difficult, if at all possible, for the Westphalian state to contain[7].

(b) it generates hyper-evolution with an important acceleration in the diffusion of General Purpose Technologies 'GPTs' that, because of the advantages of scaling and learning, prompt concentration and lead a small number of players to control the levers of the global economy.

(c) it is characterized by omni-use, as GPTs are adapted in different settings and economic sectors, which engenders inter-market feedback loops and technological convergence (the intersection of biology and digital technology, bio-digital, being the most recent example).[8]

(d) it is driven by autonomy, to the extent that autonomous systems interact with their surrounding environment independent of human action, which has "the potential to produce [a] set of novel hard-to predict effects" making the forecasting of threats excessively difficult.[9]

These new "synthetic" worlds bring changes to the existing socio-economic and institutional systems, raising novel threats of harm that may not be predicted by knowledge systems, such as neoclassical economics, that are mostly focusing on linear processes, assume

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[2] KLAUS SCHWAB, THE FOURTH INDUSTRIAL REVOLUTION (2016).
[3] MUSTAFA SULEYMAN, THE COMING WAVE – AI, POWER AND THE 21ST CENTURY GREATEST DILEMMA (Penguin 2023).
[4] HERBERT SIMON, THE SCIENCES OF THE ARTIFICIAL (3d ed. MIT Press 1996).
[5] SULEYMAN, *supra* note 3 at 281.
[6] *Id.* at 104-115.
[7] The terminology of "empire" borrows from ANU BRADFORD, DIGITAL EMPIRES (OUP, 2023).
[8] Policy Horizons Canada, *Exploring Biodigital Convergence: What Happens When Biology and Digital Technology Merge?,* GOVERNMENT OF CANADA (2019), https://publications.gc.ca/collections/collection_2021/hpc-phc/PH4-185-2019-eng.pdf .
[9] SULEYMAN, *supra* note 3 at 114.

competitive markets and human agency and often ignore the impact of technological change[10]. They will naturally require the legal system to adapt to such higher uncertainty. The new techno-structure will require unique legal coding, to allow its seamless operation and expansion.[11] In the field of competition policy this evolution alters human intervention in markets, either by displacing human activity at the production level or by enabling mass personalization at the demand level.[12] Such developments also profoundly reshape the "operational foundation of business", as scalable AI-driven processes lead to looser forms of economic organisation and affect the way value is produced.[13] Moreover, in view of the four abovementioned features, these "synthetic" worlds are characterised by the emergence of complex systems made up of a large number of parts that do not interact in a simple or predictable way.[14]

Competition law intervention alone will be insufficient to address all potential threats posed by this incoming wave[15], but competition authorities have nonetheless already attempted to predict possible threats of harm.[16] As a result regulators often take action before these harms

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[10] For a criticism of such "simple economics" approaches, see GIOVANNI DOSI, THE FOUNDATIONS OF COMPLEX EVOLVING ECONOMIES 11 (Oxford University Press 2023); WOLFRAM ELSNER, TORSTEN HEINRICH & HENNING SCHWARDT, THE MICROECONOMICS OF COMPLEX ECONOMIES: EVOLUTIONARY, INSTITUTIONAL, NEOCLASSICAL, AND COMPLEXITY PERSPECTIVE (Academic Press, 2014).

[11] *See* KATHARINA PISTOR, THE CODE OF CAPITAL: HOW THE LAW CREATES WEALTH AND INEQUALITY (Princeton University Press 2019)

[12] Ashok Kumar, *From mass customization to mass personalization: a strategic transformation*, 19 INT. J. FLEX. MANUF. SYST. 533 (2007).

[13] *See* MARCO IANSITI & KARIM. R. LAKHANI, COMPETING IN THE AGE OF AI 3-8, 30-32 (Harvard Business Review Press 2020).

[14] *See* Herbert. A. Simon, *The Architecture of Complexity*, 106 PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY 467, 468 (1962) which provides the original definition of complex systems as a system "made up of a large number of parts that interact in a non-simple way" and in which "the whole is more than the sum of the parts" and thus "it is not a trivial matter to infer the properties of the whole".

[15] For instance, existential risks associated with AI and synthetic biology, impact on employment, higher risks of regulatory capture etc. *See* ARVIND NARAYANAN & SAYASH KAPOOR, AI SNAKE OIL (Princeton University press, 2024).

[16] *See* Staff in the Bureau of Competition & Office of Technology, *Generative AI Raises Competition, Concerns* FEDERAL TRADE COMMISSION (29 June 2023,) https://www.ftc.gov/policy/advocacy-research/tech-at-ftc/2023/06/generative-ai-raises-competition-concerns; Autoridade da Concorrencia, *Competition And Generative Artificial Intelligence,* AUTORIDADE DA CONCORRENCIA (2023). https://www.concorrencia.pt/sites/default/files/documentos/Issues%20Paper%20-%20Competition%20and%20Generative%20Artificial%20Intelligence.pdf; Competition Markets Authority (CMA), *Horizon Scanning; Trends in Digital Markets: a CMA horizon scanning report,* GOV.UK (2023), https://www.gov.uk/government/publications/trends-in-digital-markets-a-cma-horizon-scanning-report; Competition Markets Authority (CMA), *AI Foundation Models: Short version*, GOV.UK (September 2023), https://assets.publishing.service.gov.uk/media/65081d2c4cd3c3000d68cb6d/Short_version_.pdf; Autorité de la concurrence, *Generative artificial intelligence: the Autorité issues its opinion on the competitive functioning of the sector*, AUTORITÉ DE LA CONCURRENCE (June 28, 2024), https://www.autoritedelaconcurrence.fr/en/press-release/generative-artificial-intelligence-autorite-issues-its-opinion-competitive; Austrian Federal Competition Authority, *Competition in Virtual Worlds and Generative AI*, BUNDESWETTBEWERBSBEHÖRDE (2024), https://www.bwb.gv.at/fileadmin/user_upload/Barrierefrei_Competition_in_Virtual_Worlds_and_Generative_AI.pdf .

materialize or a solid scientific consensus has emerged, largely due to the fear that absent this precautionary approach it will be difficult and costly to mitigate the possible threats. The four features of the "incoming wave" and the complexity of the system (through the operation of network effects, feedback loops and cascade effects) further intensify this perception of urgency despite the simultaneous fuelling of uncertainty.

As competition authorities increasingly focus on future risks ("future gazing"), it is important to consider how legal technologies can address potential threats of harm. This work explores the hypothesis that the precautionary principle, a legal concept dealing with unpredictability, may play a more prominent role in guiding competition authorities' actions, particularly in relation to emerging technologies like AI. The text first examines the precautionary principle and its potential application in competition law (Section I). It then delves into the regulatory debate surrounding perceived harms to competition from these technologies, and provides critique of the accompanying economic assessments (Section II). The focus of this text is on the legal technologies of precautionary action in competition law that are available to address the threats posed by AI and other emerging technologies (Section III). In conclusion, the precautionary principle offers a vital framework for competition authorities and courts to proactively address potential competition distortions posed by artificial intelligence and the coming wave of new technologies. By enabling preventive intervention before irreversible competitive harm occurs, this approach helps safeguard market dynamics and innovation while managing the unique challenges posed by the transformative impact of generative AI and, more generally, autonomous complex systems.

I. PRECAUTIONARY PRINCIPLE AND COMPLEXITY

A. Uncertainty and the Scope of Intervention of the Precautionary Principle

The precautionary principle[17] usually comes into effect in the presence of decision-making under conditions of uncertainty, particularly in circumstances of extraordinary risk and significant ignorance about the future consequences of an action.[18] The use of the precautionary principle complements, and in specific circumstances substitutes, Ordinary Risk Management (ORM) approaches.

[17] Tanja Rechnitzer, *Precautionary Principles*, INTERNET ENCYCLOPEDIA OF PHILOSOPHY, https://iep.utm.edu/pre-caut/.
[18] ALAN RANDALL, RISK AND PRECAUTION 5 (Cambridge University Press 2011).

ORM approaches rely on cost-benefit analysis and the neoclassical economics' (utilitarian) reliance on the expected utility, both of which form the foundations of the standard framework of analysis in competition economics. Cost-benefit analysis compares the present values of an action (and a counterfactual without the specific action), under the assumption of a deterministic world "in which all relevant relationships are known without error". However, in reality two kinds of error frequently kick in: statistical error due to "random elements in the system" not accounted for, and deficiencies in our knowledge such as biased estimates.[19] In order to deal with such errors, neoclassical economics follows an axiomatic analysis of preferences that examines the expected behaviour by an "idealized individual". Such examination supposes that individuals' utility functions are derived from preferences over risky alternatives (lotteries or gambles), which are considered as a probability distribution over a *known* finite set of outcomes (the expected utility hypothesis).[20] This replaces expected values with deterministic values.[21] The expected utility hypothesis was originally formulated to be used with probabilities known *ex ante* (objective uncertainties, e.g. the probability that a coin may fall heads or tails). The validity of its assumptions depends on "whether it yields sufficiently accurate predictions about the class of decisions with which the hypothesis deals."[22] One may also integrate a degree of risk aversion in the cost-benefit analysis to accommodate uncertain prospects[23] by estimating an option price (i.e. estimating the Willingness to Pay for the option of future use).[24]

However, ORM approaches present many deficiencies that may question their use in context of decision-making under uncertainty. First, one might argue that probabilities are not objective in the sense of relative frequency, but rather are subjective, reflecting an agent's personal belief in the occurrence of an event. ORM attempts to combine an individual's personal utility function with its subjective probability distribution (subjective expected utility hypothesis).[25]

Second, in analysing a situation, it's essential to recognise the potential impact of uncertainty and ignorance. There are three distinct epistemic situations to consider: (i) (Knightian) risk - in this scenario, the possible outcomes of an action are known in advance,

[19] *Id.*at 49.
[20] Milton Friedman & Leonard J. Savage, *The Expected-Utility Hypothesis and the Measurability of Utility*, 60(6) J. POLITICAL ECON. 463 (1952)
[21] RANDALL, supra note 18 at 49.
[22] Freidman & Savage, supra note 20
[23] *See* Scott Farrow, *Using risk assessment, benefit-cost analysis, and real options to implement a precautionary principle*, 24(3) RISK ANALYSIS 727 (2004).
[24] RANDALL, *supra* note 18 at 50.
[25] LEONARD J. SAVAGE, THE FOUNDATIONS OF STATISTICS (Wiley 1954).

along with their relative likelihood, such that the probabilities can be expressed as relative frequencies. (ii) (Knightian) uncertainty - in this situation, there is no empirical or theoretical basis for assigning probabilities to outcomes;[26] (iii) different degrees of ignorance[27], where there is lack of knowledge about outcomes and probabilities are unknown[28] (situations of "gross ignorance" or "unknown unknowns").[29]

Third, possible outcomes of an action (or inaction) may be characterized either by strong irreversibility if the costs of reversing are insurmountable, or weak if the costs of revesting an action are modest[30]. Risks also may not be idiosyncratic but systemic, in which case standard techniques of ORM may not operate well as they focus on the central tendency of the distribution and often ignore cascading effects. This is particularly the case in complex systems (e.g. network effects) that generate "fat tails" of high-damage outcomes, and thus generally underestimate the costs of High-Impact Low Probability (HILP) events.[31]

Fourth, and relatedly, ORM approaches take a Newtonian approach[32] and use reductionist models that examine the interaction of "elemental components with defined properties" to describe the operation of a system and to estimate impacts; they assume linear changes and a stable system that naturally returns to, or is close to, its initial equilibrium point following external shocks.[33] However, in the world of complex adaptive systems, interactions are non-liner and involve feedback loops and reciprocal dependence, thus changing dynamically over time. The system's evolution and response to external shocks or stimuli is affected by its prior path and hysteresis.[34] Such complex systems give emergence to new features which could not be predicted from their current specifications (e.g. tipping points),[35] and are characterized by sudden, drastic and eventually irreversible regime shifts.[36] Managing

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[26] *See* FRANK H. KNIGHT, RISK, UNCERTAINTY AND PROFIT Chapter VII (Houghton Mifflin Company, 1921).
[27] DANIEL STEEL, PHILOSOPHY AND THE PRECAUTIONARY PRINCIPLE – SCIENCE, EVIDENCE, AND ENVIRONMENTAL POLICY 18 (Cambridge University Press 2015)
[28] Stephen M. Gardiner, *A Core Precautionary Principle*, 14(1) J. POLITICAL PHILOS. 33 (2006)
[29] Alan Randall, *We Already Have Risk Management - Do We Really Need the Precautionary Principle?*, 3(1) INT. REV. ENVIRON. RESO. 39 (2009)
[30] STEEL, *supra* note 27 at 58-59.
[31] RANDALL, *supra* note 18 at 76-78.
[32] *Id.*at 63.
[33] *Id.*
[34] *Id.*at 64-65.
[35] *Id.*
[36] *See* W. BRIAN. ARTHUR ET AL., THE ECONOMY AS AN EVOLVING COMPLEX SYSTEM II (CRC Press 1997); JOHN H. MILLER & SCOTT E. PAGE, COMPLEX ADAPTIVE SYSTEMS – AN INTRODUCTION TO COMPUTATIONAL MODELS OF SOCIAL LIFE (Princeton University Press 2007); J. Stephen Lansing, Complex Adaptive Systems, 32 ANNU. REV. ANTHROPOL 183 (2003)

such complex systems requires new approaches of adaptive iterative processes that aim to reduce uncertainty over time ("groping in the dark").[37]

In conclusion, ORM may suffer in situations of decision-theoretic uncertainty, when there is knowledge over the possible outcomes of a potential action but it is difficult or impossible to establish the probabilities. The problem is more acute in the context of decision-theoretic ignorance, when there is no available knowledge of the set of possible outcomes of a potential action. Precautionary principles may support decision-making in these contexts, and prevent decision-theoretic uncertainty or ignorance causing harm for welfare or some other value inaction.

B. The content of the precautionary principle

From a practical decision-making perspective, one may distinguish between different interpretations of the precautionary principle: (i) it may provide some parameters to select a course of action given specific circumstances of decision-theoretic risk, (ii) it may set some epistemic standards to provide insights as to what one should reasonably believe under conditions of uncertainty, and (iii) it may denote procedural guidelines to express requirements for decision-making.[38]

According to Randall, there are three important elements for the operation of the precautionary principle: harm, uncertainty and action (remedy).[39] The precautionary principle may be triggered when there is a "sufficient" level of "scientific and credible evidence" of a threat (chance) of harm requiring some precautionary response.[40] A "weak" precautionary principle suggests that, in the presence of serious risks, uncertainty is normally not sufficient to justify inaction.[41]. Alternatively, a "strong" precautionary principle imposes a "de minimis condition" after which the principle is triggered[42], meaning it is "determinative" as regulators are "required to act on it".[43]

[37] DONELLA MEADOWS ET AL., GROPING IN THE DARK: THE FIRST DECADE OF GLOBAL MODELLING (Wiley 1982).
[38] Marko Ahteensuu & Per Sandin, *The Precautionary Principle in* HANDBOOK OF RISK THEORY (Sabine Roeser et al. eds., 2012).
[39] RANDALL, *supra* note 168 at 102.
[40] *Id.*
[41] Gardiner, *supra* note 28 at 43.
[42] STEEL, *supra* note 27 at 3.
[43] Gardiner, *supra* note 28 at 45.

Harm refers to threat of harm (chance of harm), that is "an indication of impeding harm or a signal correlated with future harm."[44] This expands the situations of uncertainty over harm beyond Knightian uncertainty to include situations of gross ignorance or "unknowns unknowns". Uncertainty relates to the operational concept of evidence and concerns knowledge regarding unpredictability of outcomes and likelihoods as well as potentially "the failure to know everything that is knowable."[45] Uncertainty can be explained in three ways; 'decision-theoretic' perspective refers to the absence of empirical evidence of outcomes, 'scientific uncertainty' hints at the absence of a predictive model[46], and 'axiological uncertainty' focuses on the lack of value assumptions[47]. Another option would be to adopt scientifically sound, and simplified "precautionary defaults"[48] to deal with regulatory decisions in the face of insufficient information – these could take the form of presumptions that may be triggered by certain events/criteria, or alternatively by cautious or pessimistic assumptions considered when interpreting the available evidence.[49]

Finally, remedial actions under the precautionary principle look stronger than those prescribed by ORM, as the principle's implementation aims to proactively avoid, mitigate and/or be tailored to the underlying threat of harm. Precautionary remedies develop in a stepwise, sequential, iterative process so as to generate regulatory learning about the threat of harm[50]. Hence, one should assess the seriousness of a threat, its potential for harm, and the reversibility of that harmful outcome, before proceeding to "reasonable" measures.[51] Steel conceptualizes the principle of precaution as a "meta-rule" which "imposes general constraints on how […] decisions are made,"[52] a decision rule[53] "that selects among concrete policy options", and as an epistemic rule "requiring that a high standard of evidence be satisfied before a new technology is accepted as safe."[54]

Steel also observed that the precautionary principle is relevant when a decision involves "a trade-off between short-term gain […] against a harm that is uncertain or spatially or

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[44] *Id.* at 103.
[45] *Id.* at 105.
[46] STEEL, *supra* note 27 at 96.
[47] David B. Resnik, *Is the precautionary principle unscientific?,* 34 STUD. HIST. PHIL. BIOL. & BIOMED. SCI. 329, 334 (2003)
[48] Per Sandin et al., *Precautionary Defaults—A New Strategy for Chemical Risk Management*, 10(1) HUM. ECOL. RISK ASSESS. 1 (2004)
[49] Rechnitzer, *supra* note 17.
[50] RANDALL, *supra* note 18 at 107.
[51] David B. Resnik, *The Precautionary Principle and Medical Decision Making*, (29)3 J. MED. PHILOS. 281 (2004)
[52] See also Rechnitzer, *supra* note 17.
[53] Rechnitzer, *supra* note 17.
[54] STEEL, *supra* note 27 at 2, 10-11.

temporally distant."[55] He observes that such decisions involve, first, a "meta-precautionary principle" to restrict the sorts of rules used and to avoid the paralysis resulting from scientific uncertainty. Secondarily he emphasizes that any precautionary measure adopted should be proportional to the plausibility and the severity of the threat.[56] It results from the above that the principle may intervene in a wide set of circumstances, not just those involving unquantifiable probabilities.[57]

Having determined the conceptual contours of the precautionary principle, we now delve in to the question of whether, when compared to traditional ORM approach, it might better explain the action of competition authorities regarding the possible action on the market of novel technologies such as AI.

II. PERCEIVED THREATS OF COMPETITION HARM OF AI AND THE TECHNOLOGIES OF THE "INCOMING WAVE"

Competition authorities have been criticized for their slow and inadequate handling of the challenges posed by the digital economy and the Big Data revolution, often intervening only once the digital markets have tipped.[58] Some courts, including the Court of Justice of the European Union (CJEU), were quick to highlight the need for a precautionary approach in competition law to respond to digital developments,[59] however this suggestion was ignored by competition authorities. This historic failure to grasp the technological changes transforming the competition landscape has evidently urged competition authorities to become more proactive in recent years. Significant breakthroughs on the AI front (machine learning, Large Language Models), have been immediately met with scrutiny from competition authorities who have published a number of reports identifying threats of harm and wrestling with possible remedies.[60]

This analysis explores various AI-related concerns through the lens of precautionary intervention, drawing upon Randall's threefold classification of threats. Rather than attempting an exhaustive examination, I focus on establishing the evidential foundation of these concerns

[55] *Id.* at 9.
[56] *Id.* at 9-10.
[57] *Id.* at 15-16.
[58] See UNCTAD, *Enforcing competition law in digital markets and ecosystems: Policy challenges and options TD/B/C.I/CLP/74*, UNITED NATIONS CONFERENCE TRADE AND DEVELOPMENT (July 2024), https://unctad.org/system/files/official-document/ciclpd74_en.pdf.
[59] Konkurrensverket v TeliaSonera Sverige AB, Case C-52/09 (Court of Justice of European Union 2011)
[60] See, below the references in Sections II.A. and II.C.

and analyzing the nature of identified threats. Randall distinguishes between: (a) novel threats, typically emerging from new technologies, which can be predicted and prevented before they materialize; (b) threats arising from "business-as-usual" practices that involve ongoing exploitation, where cumulative stress factors and regime shifts may eventually cause harm - these are particularly challenging to address as they stem from complex matrices of stressors, making both elimination and remediation costly; and (c) threats that, while novel, only appear harmful once widely dispersed (based on ex post knowledge), but may be relatively simpler to remediate as they can be attributed to a single agent or factor.[61]

This framework provides a valuable analytical lens for examining the evolution of competition authorities' responses to AI-related challenges. Initially, these authorities, along with academia, concentrated on algorithmic collusion - a classic example of a type (a) threat that could be anticipated and eventually addressed proactively. However, as AI adoption has expanded across the economy, attention has shifted to exploitation concerns affecting consumers and trade partners due to corporate extraction strategies and the imposition of unfair terms to business or end-users of these novel technologies, which align with Randall's type (c) threats. Most recently, focus has turned to three interrelated concerns: the high economic concentration within various segments of the AI stack, the widespread deployment of algorithms throughout the economy, and the inherent characteristics of these technologies as potential sources of exploitation and value capture - primarily falling under Randall's type (b) classification.

A. Algorithmic Collusion[62]

Since the publication of an open letter by 70 scientists calling for more research on the societal impacts of artificial intelligent technologies[63], and *US v. Topkins*[64] in which the US DOJ examined the use of complex pricing algorithms for the first time,[65] the possibility of collusion

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[61] RANDALL, *supra* note 18 at 136.
[62] This Section partly draws on Ioannis Lianos et al., *Chapter 8: Algorithmic Collusion and Competition Law* in BRICS DIGITAL ERA COMPETITION BRICS REPORT (2019), https://ssrn.com/abstract=3901413.
[63] *See Research Priorities for Robust and Beneficial Artificial Intelligence: An Open Letter*, FUTURE OF LIFE (October 28 2015), https://futureoflife.org/ai-open-letter/.
[64] *See* Office of Public Affairs, *Former E-Commerce Executive Charged with Price Fixing in the Antitrust Division's First Online Marketplace Prosecution*, U.S. DEPARTMENT OF JUSTICE (April 6 2015), https://www.justice.gov/opa/pr/former-e-commerce-executive-charged-price-fixing-antitrust-divisions-first-online-marketplace
[65] *See also* Competition Markets Authority, *Online sales of posters and frames*, GOV.UK (September 30 2016), https://www.gov.uk/cma-cases/online-sales-of-discretionary-consumer-products .

by algorithms (and autonomous algorithmic collusion) has become a topic of intense policy debate.[66] The language game of competition law had so far only involved humans and their firms, and with the advent of AI is now faced with the introduction of computers/algorithms some new "players" in the game.[67] Online retailers use software programs to monitor prices of their competitors[68] and adjust their own prices in response. Simultaneously, consumers may also benefit from the use of algorithms through reduced search and transaction costs and personalised product recommendations.[69]

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[66] *See* Salil K. Mehra, *Antitrust and the Robo- Seller: Competition in the Time of Algorithms*, 100 MINN. L. REV. 1323 (2016); ARIEL EZRACHI & MAURICE E. STUCKE, VIRTUAL COMPETITION (Harvard University Press 2016); Andreas Heinemann & Aleksandra Gebicka, *Can Computers Form Cartels? About the Need for European Institutions to Revise the Concertation Doctrine in the Information Age*, 7(7) JECLAP 431 (2016); Ariel Ezrachi & Maurice E. Stucke, *Artificial Intelligence & Collusion: When Computers Inhibit Innovation*, U. ILL. L. REV. 1775 (2017); Nicolas Petit, *Antitrust and Artificial Intelligence: A Research Agenda,* 8(6) JECLAP 361 (2017); Michael Gal, *Algorithmic-facilitated Coordination*, ORGANISATION FOR ECONOMIC CO-OPERATION DEVELOPMENT (22 June 2017), https://one.oecd.org/document/DAF/COMP/WD(2017)26/en/pdf; Competition & Markets Authority (CMA), Pricing algorithms: Economic working paper on the use of algorithms to facilitate collusion and personalized pricing, GOV.UK (October 8 2018), https://assets.publishing.service.gov.uk/media/5bbb2384ed915d238f9cc2e7/Algorithms_econ_report.pdf; Ulrich Schwalbe, *Algorithms, Machine Learning and Collusion*, 14(4) J. COMP. LAW ECON 568 (2018); Ioannis Lianos et al., *Chapter 8: Algorithmic Collusion and Competition Law* in BRICS DIGITAL ERA COMPETITION BRICS REPORT (2019), https://ssrn.com/abstract=3901413; Ai Deng, *Algorithmic Collusion and Algorithmic Compliance: Risks and Opportunities*, GLOBAL ANTITRUST INSTITUTE REPORT ON THE DIGITAL ECONOMY (2020), https://gaidigitalreport.com/wp-content/uploads/2020/11/Deng-Algorithmic-Collusion-and-Algorithmic-Compliance.pdf; Stephanie Assad et al., *Autonomous Algorithmic Collusion: Economic Research and Policy Implications*, 37(3) OX. REV. ECON. POLICY 459 (2021); Organisation for Economic Co-operation and Development, *Algorithmic Competition - OECD competition policy roundtable background note*, OECD PUBLISHING (2023), www.oecd.org/daf/competition/algorithmic-competition-2023.pdf; Renato Nazzini & James Henderson, *Overcoming the Current Knowledge Gap of Algorithmic "Collusion" and the Role of Computational Antitrust*, IV STAN. COMPUTATIONAL ANTITRUST 1 (2024); Ai Deng, *What Do We Know About Algorithmic Collusion Now? New Insights from the Latest Academic Research*, (February 19 2024), https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID4800990_code1399642.pdf?abstractid=4521959&mirid=1&type=2.

[67] JOHN R. SEARLE, THE CONSTRUCTION OF SOCIAL REALITY (Free Press 1995). Thank you to Hamid Ekbia for making this point.

[68] Zach Y. Brown & Alexander MacKay, *Competition in Pricing Algorithms*, 15 AM. ECON J.: MICROECON.109 (2023)

[69] *See* Organisation for Economic Co-operation and Development, *Algorithms and Collusion: Competition Policy in the Digital Age*, OECD ILIBRARY (2017) https://www.oecd-ilibrary.org/docserver/258dcb14-en.pdf?expires=1729071455&id=id&accname=guest&checksum=E3F00E9527E7D95472D06C3DCA2FBE86#:~:text=This%20paper%20describes%20how%20algorithms,even%20require%20any%20human%20interaction.

As public authorities explored the threat of algorithms "offering opportunities to firms to achieve collusive outcomes in novel ways"[70], economic literature[71] soon distinguished three possibilities of algorithmic collusion: (a) conventional collusion enabled by pre-programmed pricing algorithms that use strategies to facilitate collusion, (b) collusion through third party pricing, e.g. software companies providing competing firms with similar algorithms, and (c) algorithmic collusion facilitated solely through coordination by sophisticated pricing algorithms, without explicit communication from humans.[72] For our purposes, the focal point is the kind of evidence relied upon for this economic consensus to slowly emerge.

The first wave of scientific evidence analysed simple algorithms (playing as rational players with limited memory and reasoning capacity)[73] to assess collusion by oligopolies in the framework of non-cooperative repeated games (alluding to the reality that interactions between players in a market usually occur repeatedly over time). Several contributions by Ariel Rubinstein, Itzhak Gilboa or Ehud Kalai used finite automata, considered as very simple types of algorithms, to model bounded rationality.[74] In 2015, Bruno Salcedo found that when four conditions were met simultaneously, namely that firms set prices through algorithms that can respond to market conditions (1), these algorithms are fixed in the short run (2), can be decoded by the rival (3), and can be revised over time (4), then every long run equilibrium of the game led to monopolistic, or collusive, profits.[75]

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[70] *Id.*; Competition and Market Authority, *Pricing Algorithms - Economic Working Paper on The Use of Algorithms to Facilitate Collusion and Personalised Pricing*, GOV. UK (2018), https://assets.publishing.service.gov.uk/media/5bbb2384ed915d238f9cc2e7/Algorithms_econ_report.pdf; German Monopolies Commission, *Algorithms and Collusion: Excerpt from Chapter I of the XXII. Biennial Report of the Monopolies Commission ("Competition 2018") in accordance with Section 44 Paragraph 1 Sentence 1 of the German Act against Restraints of Competition*, MONOPOLKOMMISSION (2018), https://www.monopolkommission.de/images/HG22/Main_Report_XXII_Algorithms_and_Collusion.pdf; Bundeskartellamt and Autorité de la Concurrence, *Algorithms and Competition*, AUTORITÉ DE LA CONCURRENCE (November 2019), https://www.autoritedelaconcurrence.fr/sites/default/files/algorithms-and-competition.pdf .

[71] *See* Emilio Calvano et al., *Algorithmic Pricing: What Implications for Competition Policy?*, 55(1) REV. INDUSTRIAL ORG. 155 (2019); Emilio Calvano et al., *Artificial Intelligence, Algorithmic Pricing, and Collusion*, 110(1) AM. ECON. REV. 3267 (2020).

[72] Joseph E. Harrington, *Developing Competition Law for Collusion by Autonomous Artificial Agents*, 14(3) J. COMP. LAW ECON. 331 (2018); Joseph E. Harrington, *Competition Law and Pricing Algorithms*, Bergen Competition Policy Conference (April 2019).

[73] *See also* Eric Maskin & Jean Tirole, *A Theory of Dynamic Oligopoly, I: Overview and Quantity Competition with Large Fixed Costs*, 56(3) ECONOMETRICA 549 (1988); Eric Maskin & Jean Tirole, *A Theory of Dynamic Oligopoly, II: Price Competition, Kinked Demand Curves, and Edgeworth Cycles*, 56(3) ECONOMETRICA 571 (1988).

[74] Ariel Rubinstein, *Finite Automata Play the Repeated Prisoner's Dilemma*, 39 J. ECON. THEORY 83 (1986); ARIEL RUBINSTEIN, MODELING BOUNDED RATIONALITY (MIT Press 1998); Itzhak Gilboa, *The Complexity of Computing Best-Response Automata in Repeated Games*, 45 J. ECON. THEORY 342 (1988); Ehud Kalai, *Bounded Rationality and Strategic Complexity in Repeated Games* in GAME THEORY AND APPLICATIONS 131-157 (Tatsuro Ichiishi et al. eds., 1990).

[75] BRUNO SALCEDO, PRICING ALGORITHMS AND TACIT COLLUSION (Pennsylvania State University 2015).

The second type of referenced scientific evidence pertained to computer simulated experiments where pricing algorithms in controlled (synthetic) environments, were analysed in their ability to sustain collusive strategies, and their speed of convergence to above-competitive prices. Substantial attention was given in economics literature to reinforcement machine learning including Q-learning algorithms, where agents learn from interacting autonomously through trial and error with their environment.[76] Emilio Calvano and others[77] studied experimentally the behaviour of algorithms powered by Q-learning in a workhorse oligopoly model of repeated price competition and found that the algorithms consistently learned to charge supra-competitive prices, without communicating with one another or such strategies being pre-programmed in their design.[78] However, as Timo Klein noted many of these results were either not robust to small fluctuations in the payoff function, or did not seem to be based on equilibrium behaviour[79].

The third type of evidence, empirical work on the use of algorithms and the risk of collusion, has been relatively rarer.[80] In a seminar paper, Assad et al. explored the use of algorithmic pricing in the German retail gasoline market and concluded that widespread adoption could facilitate collusive behaviour. Irrespective of the type of learning algorithms adoption made deviations from collusive conduct easier to detect and punish, thus making supra-competitive prices easier to sustain.[81]

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[76] *See* Timo Klein, *Assessing Autonomous Algorithmic Collusion: Q-Learning under Sequential Pricing*, RAND JOURNAL OF ECONOMICS (2019); Gerald Tesauro & Jeffrey O. Kephart, *Pricing in Agent Economies Using Multi-Agent Q-Learning*, 5 AUTONOMOUS AGENTS AND MULTI-AGENT SYSTEMS 289 (2002); Ludo Waltman & Uzay Kaymak, *Q-learning Agents in a Cournot Oligopoly Model*, 32 J. ECON. DYN. CONTROL 3275 (2008).

[77] Emilio Calvano et al., *Artificial Intelligence, Algorithmic Pricing, and Collusion*, CEPR Discussion Paper 13405 (2018).

[78] *See* Andréa Epivent & Xavier Lambin, *On Algorithmic Collusion and Reward-Punishment Schemes,* SSRN (February 17 2023), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4227229, for a criticism of this experimental setting that shows that the apparent reward-punishment schemes learnt by the algorithms under Calvano et al. "may not be fully rational and may stem from the imperfection of the learning process, rather than algorithmic sophistication", collusion being "not the only possible explanation on apparent punishments or supracompetitive profits of AIA (Artificial Intelligence Algorithm)"; Arnoud. V. den Boer, et al., *Artificial Collusion: Examining Supracompetitive Pricing by Q-learning Algorithms*, Amsterdam Law School Research Paper No. 2022-25, SSRN (2022), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4213600, noting that "the simulations presented by Calvano et al. do not give sufficient evidence for the claim that these types of Q-learning algorithms systematically learn collusive strategies"; Leon Mussolf, *Algorithmic Pricing, Price Wars and Tacit Collusion: Evidence from E-Commerce* (March 27 2024), https://lmusolff.github.io/papers/Algorithmic_Pricing.pdf.

[79] *See* Timo Klein, *The risks of using algorithms in business: artificial price collusion*, OXERA (2020), https://www.oxera.com/insights/agenda/articles/the-risks-of-using-algorithms-in-business-artificial-price-collusion/.

[80] *See* Le Chen et al., *An Empirical Analysis of Algorithmic Pricing on Amazon Marketplace*, 25TH INTERNATIONAL CONFERENCE ON THE WORLD WIDE WEB (2016), https://dl.acm.org/doi/10.1145/2872427.2883089.

[81] Stephanie Assad et al., *Algorithmic Pricing and Competition: Empirical Evidence from the German Retail Gasoline Market*, CESifo Working Paper No. 8521 (2020), https://ssrn.com/abstract=3682021 .

It can be concluded that at the time the debate on algorithmic collusion took off in the mid-2010s, the few existing theoretical models and experimental studies revealed that it was possible for firms using pricing algorithms to reach and sustain collusive outcomes but there was no consensus[82] as to the nature or level of the threat to market competition. Writing in 2020, Schrepel argued that "algorithmic collusion is a fundamentally unimportant subject for antitrust and competition law", noting both the lack of significant empirical evidence and relevant cases brought by the competition authorities in the EU and the US.[83] Later in 2023, Assad et al. urged for further research noting that "we are in the very early stages of both academic and applied research on pricing algorithms and collusion".[84] .

However, some emerging economic literature raises more important and distinct concerns regarding algorithmic collusion through Large Language Model (LLM) pricing agents, using simulations, as an additional source of scientific evidence about algorithms.[85] The authors find that algorithms pre-trained on very large datasets but without explicit instructions, learn to play optimally by experience[86] and have more "discretion" as to the possible interpretation of their prompts. As a result the LLM becomes "a randomized, ever-evolving 'black box' whose' intentions' are opaque and largely uninterpretable, even to its users."[87] The authors conclude that "it is conceivable that LLM-based pricing algorithms might behave in a collusive manner despite a lack of any such intention by their users" even if the textual instructions they receive are "innocuous."[88] These developments prompt us to critically examine the behavioral assumptions underlying our economic models. While traditional economics relies on predictions based on the rational "*homo economicus*," we must now grapple with how algorithmic decision-makers—what has been called "*homo silicus*"[89]—operate under fundamentally different parameters and constraints. This shift challenges our established theoretical frameworks and demands new analytical approaches to understand and

[82] Ai Deng, *What Do We Know About Algorithmic Collusion Now? New Insights from the Latest Academic Research*, (February 19 2024), https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID4800990_code1399642.pdf?abstractid=4521959&mirid=1&type=2.
[83] Thibault Schrepel, *Collusion by Blockchain and Smart Contracts*, 33 HARV. J.L. & TECH. 117 (2019), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3315182.
[84] Stephanie Assad et al., *Autonomous Algorithmic Collusion: Economic Research and Policy Implications*, 37(3) OX. REV. ECON. POLICY 459 (2021).
[85] Sara Fish et al., *Algorithmic Collusion by Large Language Models* (2024)
[86] Emilio Calvano et al., *Artificial Intelligence, Algorithmic Pricing, and Collusion*, CEPR Discussion Paper 13405 (2018).
[87] Fish, *supra* note 85 at 2.
[88] *Id.* at 3.
[89] J. J. Horton, Large Language Models as Simulated Economic Agents: What Can We Learn from Homo Silicus?, arXiv:2301.07543 (2023).

predict collusive market behavior. Despite the lack of a solid evidential basis and ensuing scientific uncertainty public authorities have not been led to inaction, the threats imposed by algorithmic collusion being tackled by new legislation (see Section III)[90].

B. Unilateral Exploitative Conduct

While competition authorities are examining threats of algorithmic and AI exploitation, including those posed by generative AI, many of these concerns represent enhanced versions of conventional antitrust issues. Traditional industrial organization models of monopolistic behavior, particularly regarding excessive pricing and other forms of exploitative conduct (e.g. unfair trading terms), remain relevant but must now account for how AI's sophisticated capabilities amplify these risks. This novel technology doesn't fundamentally alter the nature of these anticompetitive practices but rather intensifies their potential impact and reach, requiring a recalibration of traditional antitrust frameworks. For instance, the recent FTC Report on the growth of Generative AI focuses on three 'building blocks' – data, talent, and computational resources, and highlights the threats of harm arising from the concentration of the AI stack.[91] The Report highlights the potential for anticompetitive behaviour from cloud-service provides, and the increased likelihood that higher demand for server chips (needed to train AI) will be matched by "exorbitant data egress fees".[92] Alternatively, on the less conventional side, the exploitation of customers and business users is possible through personalized pricing, exploitative tying, or by simply knowing more about the customers of competitors.[93] Exploitation may thus affect both the price paid for a digital service/product and/or some non-price parameter of competition such as quality (e.g. privacy).[94]

Parallel concerns were expressed about the practice of behavioural pricing or personalised price discrimination, as sellers may be able to charge different prices depending upon a buyers' search history, or "digital shadow."[95] Tantamount to first degree price

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[90] *See also* Sumeet Ramesh Motwani et al., *Secret Collusion among Generative AI Agents* (2024) https://arxiv.org/abs/2402.07510 .
[91] Staff in the Bureau of Competition & Office of Technology, *Generative AI Raises Competition Concerns*, FEDERAL TRADE COMMISSION (29 June 2023), https://www.ftc.gov/policy/advocacy-research/tech-at-ftc/2023/06/generative-ai-raises-competition-concerns.
[92] *Id.* at 4 & 6.
[93] *Id.*
[94] *See* Nicholas Economides & Ioannis Lianos, *Restrictions on Privacy and Exploitation in The Digital Economy: A Market Failure Perspective*, 17(4) J. COMP. LAW ECON. 765 (2021).
[95] *See* Michael Gal, *Algorithmic-facilitated Coordination*, ORGANISATION FOR ECONOMIC CO-OPERATION DEVELOPMENT (22 June 2017), https://one.oecd.org/document/DAF/COMP/WD(2017)26/en/pdf noting that "(a)s more data is gathered about each consumer's preferences, a personalized 'digital profile' can be created by

discrimination, behavioural pricing has initiated calls for intervention[96], and it has been conceded that the manipulation achieved by an in depth AI-leveraged knowledge of the individual consumer's behaviour will be more intense and lead to purchases that reduce consumer welfare.[97] "Price targeting", as observed in various markets[98], enables the producer to charge a specific consumer as much as his/her willingness to pay and reduces the available income of that consumer to make other purchases. This necessitates a decrease in consumer welfare compared to the counterfactual of uniform marginal cost pricing, and could enable the producer to capture the entire consumer surplus[99]. However, for consumers whose willingness is lower than the counterfactual uniform price, 'personalised pricing' may allow them to purchase specific products they would otherwise be unable to afford. 'Personalised pricing' may therefore have ambiguous welfare effects, depending on the market structure and the trade of between the market 'appropriation' effect to consumers with high willingness to pay versus the 'market expansion' effect to consumers with a low willingness to pay.[100] Additional conventional competition concerns addressed in the economic literature were that such AI-

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algorithms, which calculates and updates each consumer's elasticity of demand in real-time. This digital shadow can then be used by suppliers to increase their profits even further, if they can price-differentiate between the offers they make to different consumers".

[96] *See* Autorité de la Concurrence & Bundeskartellamt, Competition Law and Big Data, AUTORITÉ DE LA CONCURRENCE (May 10 2016) noting that although the application of EU competition law to these practices may be debated, the German Federal Supreme Court found that the national provision against the abuse of a dominant position can include a consumer protection dimension as regards price discrimination in Entega Windpark Hausfirste II – KZR 5/10 (German Federal Supreme Court December 7 2010); Patrick Coen & Natalie Timan, *The Economics of Online Personalised Pricing*, OFFICE OF FAIR TRADING (2013), https://docplayer.net/9529539-The-economics-of-online-personalised-pricing.html; *Behavioural Economics and Its Impact on Competition Policy*, OXERA (2013), https://www.oxera.com/insights/agenda/articles/behavioural-economics-and-its-impact-on-competition-policy-a-practical-assessment/; Timonthy J. Richards et al, *Personalized Pricing and Price Fairness* 44(3) INT. J. INDUS. ORG. (2015), http://liaukonyte.dyson.cornell.edu/wp-content/uploads/2018/07/personalized_Pricing_IJIO.pdf; Ariel Ezrachi & Maurice E. Stucke, *The Rise of Behavioural Discrimination*, 37 ECLR 484 (2016); ARIEL EZRACHI & MAURICE E. STUCKE, VIRTUAL COMPETITION (Harvard University Press 2016) in Chapter 11 distinguishes "near perfect" discrimination, involving the categorisation of consumers through the harvesting of personal information collected with the help of Big Data and self-learning algorithms, from "behavioural" discrimination, which is led with the aim to trigger consumer biases and increase consumption.

[97] Daron Acemoglu, *Harms of AI* in THE OXFORD HANDBOOK OF AI GOVERNANCE 660, 668 (Justin Bullock et al. eds., 2022).

[98] Marc Bourreau et al., *Big Data and Competition Policy: Market Power, personalised pricing and advertising*, CENTRE ON REGULATION IN EUROPE 40-41 (February 2017), https://cerre.eu/wp-content/uploads/2020/06/170216_CERRE_CompData_FinalReport.pdf

[99] *See* Michal Gal and Daniel Rubinfeld, *Algorithms, AI and Mergers - NYU Law and Economics Research Paper No 23-36*, ANTITRUST L.J. 25-26 (2023), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4469586, noting how algorithms facilitate price discrimination, for example by abusing customer vulnerabilities, e.g. Uber raising prices for users with low battery charges.

[100] *See* Office for Fair Trading, *The economics of online personalised pricing - OFT1488*, GOV.UK (May 2013), http://webarchive.nationalarchives.gov.uk/20140402142426/http:/www.oft.gov.uk/sharedoft/research/oft1488.pdf; Bourreau et al., *supra* note 98 at 43-45.

based discrimination may discourage consumer search, ultimately leading to sub-optimal matching of consumers to products, and aggregate higher prices for consumers.[101]

Reports by competition authorities have overlooked more systemic risks of AI being widely dispersed to different economic and social activities (cumulative effect), hinted to by the academic literature. Indeed, the potential for AI to offer "a vast psychological audit, discovering and representing the desires of society"[102] raises the risks of large-scale manipulation by powerful economic actors. Personalised pricing also presents fairness considerations (value ethics) both because of lack of transparency and the exposure of sensitive personal data.[103] Generative AI developers may also have an incentive to demand unfair conditions for access, such as rights over content created by the AI or information uploaded by end or business users - again a concern that integrates broader concerns about fairness and responsible innovation.[104]

C. Exclusionary AI-Related Theories of Harm

Exclusionary concerns also largely rely on conventional economic models about anticompetitive foreclosure and exclusion, transposed in the context of AI. Minimal attention has been devoted to differentiating these models and adapting them to the specificities of LLMs and machine learning.

It has been alleged that algorithms may allow companies to undertake predatory pricing and supra-competitive selective pricing measures[105], eliminating competitors from the market in the process.[106] For example, Uber collected data on drivers working for both them and Lyft, and offered them targeted benefits to work exclusively for Uber, thus raising the competitors' costs.[107]

Another concern commonly expressed is that a small number of the largest incumbent technology firms, with existing power in the most important digital markets, could profoundly

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[101] Mark Armstrong & Jidong Zhou, *Search Deterrence*, 83 REV. ECON. STUD. 26 (2016).
[102] WILLIAM DAVIES, THE HAPPINESS INDUSTRY: HOW THE GOVERNMENT & BIG BUSINESS SOLD US WELLBEING (Verso 2015).
[103] Economides & Lianos, *supra* note 94.
[104] Autoridade da Concorrencia, *Competition and Generative Artificial Intelligence,* AUTORIDADE DA CONCORRENCIA 37 (2023), https://www.concorrencia.pt/sites/default/files/documentos/Issues%20Paper%20-%20Competition%20and%20Generative%20Artificial%20Intelligence.pdf.
[105] *See* Einer Elhauge, *Why Above-Cost Price Cuts to Drive Out Entrants Are Not Predatory-and the Implications for Defining Costs and Market Power*, 112 YALE L.J. 681 (2003).
[106] *See* Thomas K. Cheng & Julian Nowag, *Algorithmic Predation and Exclusion*, 25 U. PA. J. BUS. L. 41 (2023).
[107] Gal & Rubinfeld, *supra* note 99 at 30-33.

shape the development of AI-related markets to the detriment of fair, open and effective competition.[108] Competition authorities have focused on the concentration at the level of the public cloud infrastructure, as well as the existence of partnerships between cloud service providers and AI foundation model providers.[109] Demand has emerged for a comprehensive review of M&A transactions and the scope of merger regulation concerning partnerships across the digital economy.[110] Simultaneously, enforcers have raised concerns about economic actors' paired access to privileged data and unique algorithms, to the extent that they may produce a snowball effect whereby a large user base allows easier access to new training data that subsequently enables significant improvement to the models and ultimately attracts an even larger user base.[111] The potential for AI and LLMs to reduce interoperability between datasets or services and place rivals at a competitive disadvantage[112] is reminiscent of existing economic thought. Despite this, it should be noted that, using user data to further refine the model in question will create a strong first-mover advantage because AI feedback loops will have a larger exclusionary potential than traditional data feedback loops.[113]

The existing barriers to the acquisition of publicly available data is a well-known concern in the context of the broader digital economy[114]. Presently, Foundational Models (FM) developers may have access to new data either by drawing on their proprietary resources to use data they have already harvested in their business activity, or by purchasing data from third party providers such as publishers and image repositories.[115] Such agreements for the sale, licensing, or sharing of user-generated content, particularly in community-driven platforms[116] have raised the spectre of exclusionary concerns for some competition regulators.[117] Although

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[108] Competition Markets Authority (CMA), *AI Strategic Update*, GOV.UK (April 29 2024), https://www.gov.uk/government/publications/cma-ai-strategic-update/cma-ai-strategic-update
[109] Autoridade da Concorrencia, *supra* note 104 at 26.
[110] See Competition Markets Authority (CMA), *CMA seeks views on AI partnerships and other arrangements*, GOV.UK (24 April 2024) https://www.gov.uk/government/news/cma-seeks-views-on-ai-partnerships-and-other-arrangements/.
[111] Autoridade da Concorrencia, *supra* note 104 at 15.
[112] Gal & Rubinfeld, *supra* note 99 at 33.
[113] Richard May, *Artificial Intelligence, Data and Competition*, OECD ARTIFICIAL INTELLIGENCE PAPERS 29-30 (May 2024), https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/05/artificial-intelligence-data-and-competition_9d0ac766/e7e88884-en.pdf.
[114] Daniel Rubinfeld & Michal Gal, *Access Barriers to Big Data*, 59 ARIZONA L. REV. 339 (2017).
[115] Competition Markets Authority (CMA), *AI Foundation Models: Short version*, GOV.UK at 1.24 (September 2023), https://assets.publishing.service.gov.uk/media/65081d2c4cd3c3000d68cb6d/Short_version_.pdf.
[116] For example, the agreement negotiated by Redddit with Big Tech companies, such as Google, or the one signed by Associated press with Open AI, to train AI models.
[117] *See* Paresh Dave, *Reddit's Sale of User Data for AI Training Draws FTC Inquiry*, WIRED (March 15 2024), https://www.wired.com/story/reddits-sale-user-data-ai-training-draws-ftc-investigation/; Kate Knibbs, Journalists Had 'No Idea' About OpenAI's Deal to Use Their Stories, WIRED (December 21 2023), https://www.wired.com/story/openai-axel-springer-news-licensing-deal-whats-in-it-for-writers/.

popular FMs such as Meta's Llama 2 and Stability AI's Stable Diffusion were pre-trained using only data scraped from the web and other publicly available data, the CMA has observed in its AI Report that "in future it could be more challenging for FM developers to improve on model performance by increasing the scale of training data because freely available data may be fully exploited (ie there is no new data that models could be trained upon) or grow at a slower rate."[118] The potential for LLMs to collapse when trained on recursively generated data means synthetic data may not be used as a cheaper training data substitute by FM developers[119] and that access to real world data forms an essential ingredient for the success of new LLMs.[120] The well-established literature on the benefits of open access models for social welfare[121] has prompted discussion on open-source vs closed-source LLMs in competition authorities' reports[122]. Both the CMA and FTC acknowledge the risk that open-source models may suddenly become closed, prompting consumer inertia[123] and locking in customers thereafter.[124]

The substantial investment in distributed computing systems, AI accelerator chips and GPUs[125] coupled with the scaling laws observed when larger models integrate more data and training parameters to perform better than smaller models[126] has streamlined competition authorities focus to the access of computing power. Scale may mean "FM development may exhibit economies of scale, as initial high model development costs (pre-training, fine-tuning) can be spread over a larger customer base", thus conferring an additional advantage to large players.[127] This concern is motivated by conventional threats of dominance and foreclosure, especially in light of the concentration of AI chips production by the US-based NVIDIA.[128]

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[118] CMA, *supra* note 115.
[119] *See* Anis Germani, *The Politics of Artificial Intelligence in Healthcare: Diagnosis and Treatment* in AI AND SOCIETY 33, 35-36 (2023); Khaled El Emam, *Could Synthetic Data be the Future of Data Sharing?*, CPO MAGAZINE (August 5 2021), https://www.cpomagazine.com/data-privacy/could-synthetic-data-be-the-future-of-data-sharing noting that the prediction accuracy for models using synthetic data tends to be within 2-5% of the original data.
[120] Ilia Shumailov et al., *AI models collapse when trained on recursively generated data*, NATURE 631, 755-759 (2024), https://doi.org/10.1038/s41586-024-07566-y.
[121] Competition Markets Authority (CMA), *AI Foundation Models Technical Update Report*, Gov.UK 50 (April 16 2024), https://assets.publishing.service.gov.uk/media/661e5a4c7469198185bd3d62/AI_Foundation_Models_technical_update_report.pdf.
[122] Staff in the Bureau of Competition & Office of Technology, *supra* note 91.
[123] *See* Economides & Lianos, *supra* note 94.
[124] CMA, *supra* note 121 at 54-55.
[125] CMA, *supra* note 115 at 1.28.
[126] CMA, *supra* note 115 at 1.31, notes "Meta's FM 'LLaMA' has 65 billion parameters and an estimated compute cost of $4 million. In contrast, the larger FM 'Megatron-Turing NLG' with 530 billion parameters has an estimated compute cost of $100 million".
[127] *Id.* at 1.36.
[128] Autoridade da Concorrencia, *supra* note 104 at 27, noting that the GPU market is also concentrated and led by Nvidia, which is developing its own Generative AI services.

The necessity of access to significant cloud computing capabilities also creates a concern for FM developers due to the high expense of in-house development and concentration of external cloud service provision to only AWS, Azure and GCP, and specialized providers such as CoreWeave.[129] The limited availability of cloud service providers creates barriers in switching providers or choosing to use multiple at the same time, through measures such as complex tariff structures, egress fees and a low level of interoperability.[130] There is an incentive for cloud computing firms, who are active in several markets, to integrate AI in other products[131] and agree one-way or two-way exclusivity agreements with FM developers to restrict access to FMs to only their cloud service in order to gain from a multi-market presence. Although it has also been noted that "once a FM completes its pre-training or fine-tuning, its performance level is essentially fixed, with the number of users having no immediate direct impact on user experience"[132], access to large volumes of feedback from different categories of users could enable multi product and service firms to improve their FMs beyond an achievable standard for smaller firms. As the CMA notes, "the greater the feedback effects, the quicker firms will be able to make their downstream FM services better, giving these firms a competitive advantage."[133]

An additional concern highlighted by the reports is vertical or quasi-vertical integration, with the presence of some firms in two or more stages of the AI value chain raising traditional concerns of leveraging and anticompetitive foreclosure[134]. There is an increasing risk of further entrenchment of market power through partnerships between the main AI players and chip manufacturers (especially Nvidia), which may have ambiguous effects from a consumer welfare perspective.[135] A recent OECD report when referring to the relationship between Microsoft and OpenAI observed that while powerful partnerships in the sector may not be raising competition issues at the moment they have the potential to be seriously deleterious in the future.[136] Indeed, as the CMA acknowledges in its AI Foundation Models Report, "(s)everal FM developers, such as Microsoft, Amazon and Google, own key infrastructure for producing and distributing FMs such as data centres, servers and data repositories."[137] This enables FM developers and their Big Tech partners, which are present in a range of user-facing

[129] CMA, *supra* note 115 at 1.11 & 1.32.
[130] Autoridade da Concorrencia, *supra* note 104 at 28.
[131] *Id.* at 34-35.
[132] CMA, *supra* note 115 at 1.36.
[133] CMA, *supra* note 115 at 1.60.
[134] Gal & Rubinfeld, *supra* note 99 at 10.
[135] *See* CMA, *supra* note 121 at 18 & 75 et seq.
[136] May, *supra* note 113 at 44-45.
[137] CMA, *supra* note 115 at 1.18.

markets where FM technology can be integrated (e.g. online shopping, search, supply of software) to control various stages of the AI development and deployment process. Partnerships may adopt exclusionary strategies (e.g. restricting access to their FMs by companies outside their ecosystem, refusing to license its leading AI models, giving preferential treatment to their own downstream Generative AI at the cost of competing downstream services[138]) as well as exploitative strategies (e.g imposing exorbitant charges for the use of these FMs, introducing exploitative bundling[139], tying generative AI applications with existing products to "reduce the value of competitors' standalone generative AI offerings"[140]). A recent FTC report also highlights how M&A activity by major companies may encourage buying critical applications and cutting off access to core products, as well as buying out rivals on the market in lieu of offering better services.[141]

Access to qualified AI experts and specialized financial backing remains essential for firms, and the prevalence of non-compete clauses that restrict the ability of workers to move to rivals may exacerbate the barriers to entry[142]. As acknowledged by the OECD, "(t)he expertise required to develop a foundation model includes the necessary AI based techniques, as well as the talent to progress techniques to derive the right outcomes".[143] This reflects the concern over monopsony in labour markets originally highlighted in Joan Robinson's IO models[144].

The most recent concerns on 'ecosystemic theories of harm' expressed by academic writing are also touched upon in some reports[145], with particular attention given to the possibility that ecosystem "stickiness" and customer lock-in may be reinforced by the use of AI. Some reports highlight that FMs may often integrate into existing digital ecosystems (i.e. mobile platforms, search engines, productivity software), providing the controlling players the capacity to manipulate integration rules, by "funneling users toward their own generative

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[138] Autoridade da Concorrencia, *supra* note 104.
[139] CMA, *supra* note 115 at 1.58.
[140] Staff in the Bureau of Competition & Office of Technology, *supra* note 91 at 5.
[141] *Id.* at 6.
[142] *See FTC Announces Rule Banning Noncompetes,* FEDERAL TRADE COMMISSION (April 23 2024), https://www.ftc.gov/news-events/news/press-releases/2024/04/ftc-announces-rule-banning-noncompetes.
[143] Organisation for Economic Co-operation and Development Secretariat, *Artificial intelligence, data and competition - Background Note*, ORGANISATION FOR ECONOMIC CO-OPERATION DEVELOPMENT 19-20 (May 6 2024), https://one.oecd.org/document/DAF/COMP(2024)2/en/pdf.
[144] JOAN ROBINSON, THE ECONOMICS OF IMPERFECT COMPETITION 236 & 281 (MacMillan 1933).
[145] Michael G. Jacobides & Ioannis Lianos, *Regulating platforms and ecosystems: an introduction*, 30(5) *INDUSTRIAL AND CORPORATE CHANGE* 1131-1142 (October 2021); Paul Heidhues et al., *A Theory of Digital Ecosystems,* CESIFO (July 8 2024), https://www.wiwi.uni-bonn.de/koszegi/ecosystems.pdf .

AI products instead of their competitors' products"[146] and ultimately limiting consumer choice.[147]

However, it also widely recognized by these reports that AI may lead to improvements in existing products and services, enhancements in customer convenience, and the building of new types of services that offer new solutions for people and businesses.[148] In conclusion, reports by competition authorities observe both the potential disruptive impact of AI developments as well as the possibility that they may reinforce existing dominant positions, noting that it is "impossible to accurately assess what the impact on competition will be from potential new FM products and services."[149]

III. Precautionary Principle, Innovation and Competition Law: The Legal Technologies of Precautionary Action

Having considered the threats of harm envisaged by competition authorities, we proceed to a normative discussion of the potential justifications for use of the precautionary principle in the context of ongoing scientific uncertainty. A particular effort will be made to address criticisms often put forward by opponents of the precautionary principle that its implementation inherently stifles innovation. Finally, we provide a descriptive account of the various forms of precautionary intervention available to competition authorities, noting how these have been used to address threats of harm generated by the technologies of the "incoming wave" so far.

A. A Synergetic Approach to the Interaction Between the Precautionary Principle and Innovation: The Responsible/Sustainable Innovation Framework

Justifications and normative grounds for the precautionary principle vary from the failure of ordinary risk management (ORM) approaches[150], ignorance of decision makers to High Impact Low Probability (HILP) events[151] and the creation of an illusion of control[152], as well as a moral desire to consider moral "secondary effects" or "social amplifications."[153] Precautionary

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146 *Id.*
147 CMA, *supra* note 115 at 1.46 & 1.47.
148 CMA, *supra* note 115 at 1.53.
149 CMA, *supra* note 115 at 1.45.
150 Randall, *supra* note 18 at 56-80.
151 Resnik, *supra* note 47 at 333-334.
152 Sven O. Hansson, *From the Casino to the Jungle: Dealing with Uncertainty in Technological Risk*, 168(3) Synthese 423 (2009); Rechnitzer, *supra* note 17.
153 Rechnitzer, *supra* note 17.

principles have nevertheless been criticized for their conceptual incoherence. Sunstein argued that a "strong precautionary principle" would advocate for action "even if the supporting evidence is speculative and even if the economic costs of regulation are high" leading to paralysis in decision-making[154]. However, this risk may be mitigated by conducting a risk-risk trade-off and factoring in the foregone benefits of the abandoned action as possible harms of precautionary regulation.[155]

Much opposition to the application of the precautionary principle originates from the perception that it may reduce innovation incentives and stifle growth.[156] Following an examination of the opportunity and legal certainty costs arising out of the application of the precautionary principle, Portuese advocated in favour of the simultaneous use of an "innovation principle" to "balance out" the application of the precautionary principle.[157] This approach would see authorities aiming to integrate innovation at the levels of regulatory preparation and implementation, adopting agile regulatory tools such as regulatory sandboxes and innovation deals. There is nothing controversial in adopting a "weak" innovation principle, as seems is put forward by the author.[158] However, the devil is in the details. This principle is presented as antagonistic or in tension with the precautionary principle[159], but this blurs the debate and does not address the elephant in the room - that one may take a precautionary approach to the protection of innovation by maintaining the value of future innovation trajectories or open-up technological opportunities.

Indeed, innovation has multiple dimensions, some of which may significantly increase the well-being of society either now or in the future, but others may also lead to losses for certain societal groups without providing any compensating benefits. An innovation principle approach fails to consider the inherent uncertainty of the process of innovation, as only a very small minority of innovations involves situations of (Knightian) risk, with the vast majority characterized by (Knightian) uncertainty as to the probability of their success. The positive

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[154] *See* Cass R. Sunstein, *The Paralyzing Principle*, WINTER REGULATION 32 – 34 (2002-2003); CASS R. SUNSTEIN, LAWS OF FEAR: BEYOND THE PRECAUTIONARY PRINCIPLE (Cambridge University Press 2005).
[155] Rechnitzer, *supra* note 17.
[156] See Thomas A. Hemphill, *The innovation governance dilemma: Alternatives to the precautionary principle*, 63 TECH. IN SOC. 101381 (2020).
[157] Aurelien Portuese, *Precautionary Antitrust: The Changing Nature of Competition Law*, 17(3) J. L. ECON. & POLICY 548, 586, 589 & 590 (2022).
[158] He notes that this is not "a policy per se but rather an approach" which requires "further conceptualization to gain operationality within the regulatory framework" and that its aim "would be to ensure more 'evidence-and foresight-based policymaking' while not being automatically 'anti-regulatory' contrary to common beliefs".
[159] As the author does in the subsequent discussion, arguing that "precautionary antitrust" may be an impediment to innovation.

societal impact of a novel technology[160], is at best a guess and in most cases a known unknown or even an unknown unknown.[161]

In the context of scientific uncertainty about innovation and its outcomes to society, it may be advisable to adopt a precautionary principle operating for the preservation of the (chance) of innovation and the option value of future innovation. Exploring the interaction between the precautionary principle and innovation, we consider different scenarios:[162]

(a) If there is no evidence ex ante about the possibility of harmful outcomes and it is impossible/significantly costly to contain such outcomes (the threat of harm is high and the uncertainty is obvious), the remedial precautionary action may be quite strong and involve even the prohibition of the activity or innovation in question.

(b) If there is some knowledge about the possible outcomes and ex ante uncertainty about their likelihood, but it is possible to distinguish classes of cases based on their predisposition to generate serious harm or the societal aversion to harm in the relevant industry, then the remedial response should accommodate for these different situations through a categorical approach. This will reverse the burden of proof, in essence leading to a more iterative stepwise model of precautionary remedies that enables regulatory learning.

(c) If there is scientific evidence ex ante about the possible outcomes and their likelihood, then it would be possible to proceed with a case-by-case ORM approach, requiring the careful modelling of the threat of harm and the circumstances of this occurring, eventually combining this with a precautionary approach by raising the standards of evidence.

However, any discussion on innovation should not only focus on the level of innovation, as is often the case, but also on its direction.[163] There are clear societal commitments in the EU (and other major jurisdictions) towards Sustainable Development Goals (SDGs)[164] and this needs to be factored into any discussion concerning innovation.[165]

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[160] The development of General Purpose Technologies, such as the steam engine, railways, electricity, computing, the Internet, Artificial intelligence, biotechnology, usually leads to disruptive innovation and ultimately to important increases in productivity that provokes important spill-over effects to various industries and markets.

[161] *See* Boyan Jovanovic & Peter Rousseau, *Chapter 18: General Purpose Technologies* in HANDBOOK OF ECONOMIC GROWTH, 1181-1224 (Philippe Aghion & Steven Durlauf eds., 2005).

[162] *See* RANDALL, *supra* note 18 at 146-147.

[163] Ioannis Lianos, *Polycentric Competition Law,* 71(1) CURRENT LEG. PROB. 161, 175 (2018).

[164] United Nations, *Sustainable Development Goals,* DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS (2015), https://sdgs.un.org/goals.

[165] European Commission, *Proposal towards a sustainable Europe by 2030* (February 2019), https://ec.europa.eu/info/publications/towards-sustainable-europe-2030_en.

There is an ongoing dialogue in science (propelled by Polanyi's seminal work 'The Republic of Science')[166] about the need for scientists to take responsibility for the possible hazards their research may unleash, which has attracted attention to the demand for democratic governance over the innovation and technology process.[167]

Work in economic sociology and sociology of science also highlights the risk of prioritising "framing" and "overflowing" [168] in "hot situations" where there is no stabilized knowledge base, and instead proposes that "hybrid forums" composed of experts and laypeople that would take into account the debates and socio-technical controversies surrounding specific technologies would provide a more democratic context for innovation.[169] Anticipating future states of the world and future threats ("future-gazing") through hybrid forums that combine the predictive power of scientific experts with the inclusion of all possibly affected stakeholders, enables greater reflexivity on the part of actors and institutions.[170] Regulatory sandboxes may also provide similar mechanisms for anticipating negative impacts before these being generalized. These tools promote an understanding of the dynamics and shape of different technological futures and form part of the new paradigm of "responsible innovation"[171].

The concept of "responsible innovation" has broadly been described as "taking care of the future through collective stewardship of science and innovation in the present" by limiting the asymmetric power of some actors and providing "room for public and stakeholder voices to question the framing assumptions not just of particular policy issues but also of participation processes themselves."[172] It includes four dimensions: anticipation (strategic foresight), reflexivity (embedding social scientists and the legal profession in the innovation process), inclusion (democratic innovation governance), and responsiveness (greater role for regulation and standards).[173]

As such, the simplistic juxtaposition between the precautionary principle and innovation does not account for the richer and more synergetic interaction between the need

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166 Michael Polanyi et al., *The Republic of Science: Its Political and Economic Theory*, 1(1) MINERVA 54 (1962).
167 LANGDON WINNER, AUTONOMOUS TECHNOLOGY: TECHNICS-OUT-OF-CONTROL AS A THEME IN POLITICAL THOUGHT (MIT Press 1977).
168 Michel Callon, *An essay on framing and overflowing: economic externalities revisited by sociology* 46(1) SOCIOL. REV. 244 (1998).
169 MICHEL CALLON ET AL., ACTING IN AN UNCERTAIN WORLD – AN ESSAY ON TECHNICAL DEMOCRACY (MIT Press 2011).
170 Jack Stiglow et al., *Developing a framework for responsible innovation*, 42 RES. POLICY 1568, 1569-1570 (2013).
171 *Id.* at 1570.
172 *Id.* at 1571-1572.
173 *Id.* at 1573.

for a precautionary approach and the protection of responsible innovation that inspires most modern legal technologies of containment.

B. Legal Technologies of Containment: Precautionary Principle-Inspired Competition Law Interventions

In light of scientific uncertainty as to the competition implications of the new technology "wave", such as generative AI, synthetic biology and quantum computing, we can dissect different doctrines and approaches, related to both the substance of competition law and enforcement tools, that have integrated the precautionary principle approach and that may be used in this context.

1. Prohibitions and New Legislation Dealing with Novel Threats of Harm

The adoption of legislation prohibiting the use of technologies that impose unacceptable risks on society may be an option in the regulatory toolkit. This approach will usually concern novel technologies that appear *ex ante* as generating, according to the available scientific evidence, plausible threats of harm that are not addressed by the existing legislative framework (type (a) of Randall's classification discussed in Section II).

By imposing different obligations for providers (and users) of AI technology depending on the level of risk, the European Union AI Act provides an example of such regulation.[174] AI systems that pose unacceptable risks are banned, while AI systems that pose high risk are subject to prior assessment before being commercialized throughout their lifecycle. While Generative AI, such as Chat GPT, is not classified as high risk it is subject to transparency requirements due to the recognition that some high-impact general-purpose AI models may create systemic risk. However, the AI Act does not address any competition risks that may result from the use of advanced AI[175], and the only indirect reference to competition is the requirement for the European Artificial Intelligence Board and the market surveillance authorities to cooperate with the EU and national competition authorities when as part of their

[174] Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence and amending Regulations (EC) No 300/2008, (EU) No 167/2013, (EU) No 168/2013, (EU) 2018/858, (EU) 2018/1139 and (EU) 2019/2144 and Directives 2014/90/EU, (EU) 2016/797 and (EU) 2020/1828 (Artificial Intelligence Act).
[175] *Id.* at Recital 45.

reporting obligations they come across information that may be of potential interest for the application of EU competition law.[176]

The issue of algorithmic collusion has unsurprisingly been at the centre of the regulatory debate about a possible ban of AI or at least some form of *ex ante* auditing before introduction by businesses. Suggestions were made for the introduction of a *per se* prohibition on certain pricing algorithms that encouraged supra-competitive prices, as well as an antitrust liability determined by some form of algorithmic auditing and dynamic testing.[177] Some have even directly referred to Asimov's Three Laws of Robotics to adopt legal provisions and constraints, with particular focus on smart algorithms that could learn to communicate by sending messages encoded in the prices charged and the potential for sophisticated algorithms to overcome any provisions implemented.[178] Others argued for not subjecting algorithms facilitating collusion to *per se* prohibitions or bans, but for assessing them according to a structured rule of reason, balancing their negative effects on facilitating coordination with their pro-competitive effects[179], and relying on rebuttable presumptions[180] in specific scenarios that raise significant threats of harm.[181] There have also been suggestions for adjusting the standards of *ex-post* regulation, to allow the legal standard of proof to be more assertive towards the possibility of 'tacit collusion' in this context.[182] Finally, others objected to any regulation by arguing in favour of a 'business-as-usual' approach where algorithmic pricing is regarded as not posing any new problem that cannot be dealt with by current antitrust legislation.

As evidence arose regarding the potential anti-competitive threats posed by algorithms and new models were published exposing the possibility for LLMs to enhance the collusive potential of algorithms, proposals were made for stronger precautionary action. The recent *Preventing the Algorithmic Facilitation of Rental Housing Cartels Act. 2024 Bill* proposes to "[m]ake it unlawful for rental property owners to contract for the services of a company that coordinates rental housing prices and supply information", designating such arrangements as a

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[176] *Id.* at Article 66(h) & 74(2).
[177] Joseph E. Harrington, *Developing Competition Law for Collusion by Autonomous Artificial Agents*, 14(3) J. COMP. LAW ECON. 331 (2018).
[178] *See* Ulrich Schwalbe, *Algorithms, Machine Learning and Collusion*, 14(4) J. COMP. LAW ECON 568 (2018).
[179] Michal S. Gal, *Algorithms as Illegal Agreements*, 34 BERKELEY TECH. L. J. 67, 114 (2019).
[180] Defining categories of conduct which may be subject to presumptions of harm, such as by object restrictions of competition under EU competition law, also form standard applications of the precautionary principle.
[181] *See* Opinion of AG Wahl in Groupement des cartes bancaires (CB) v Commission Case C-67/ 13 P (Court of Justice of European Union 2014) at para. 54 noting that "[…] Where it is established that an agreement has an object that is restrictive of competition, the ensuing prohibition has a very broad scope, that it is to say it can be imposed as a precautionary measure and thus jeopardise future contacts, irrespective of the evaluation of the effects actually produced".
[182] Harrington, *supra* note 177.

per se violation of the Sherman Act.[183] The bill came following public outcry against a realtor 'RealPage' and its software program 'YieldStar' that aggregated private rental data to "help landlords push the highest possible rents on tenants."[184] A number of tenants filled class action suits alleging illegal price fixing[185], and the US Department Of Justice, joined by eight State Attorney Generals, filed a civil antitrust lawsuit against the company in August 2024.[186] In the meantime, the Preventing *Algorithmic Collusion Act of 2024 Bill* to expand the scope of the prohibition of the use of pricing algorithms to include those that can facilitate collusion through the use of nonpublic competitor data and to put in place an antitrust law enforcement audit tool, was introduced in the US Congress.[187]

As the use of Generative AI intensifies in different sectors of economic activity, and economic models about collusion evolve to account for the capability increases in LLMs, it is expected that some jurisdictions will slowly move to "hard" precautionary approaches that integrate bans for certain types of algorithms or require pre-authorization and extensive auditing prior to commercialisation. Similarly, recent advancements in AI and bio synthesizers as well as quantum computing may increase pressure to move to a "more licensed environment" that would address these novel threats of harm.[188]

2. *Re-Imagining Competition Standards for Interventions in Markets*

It has been a constant perspective of recent reports commissioned by competition authorities regarding the digital economy that the existing competition law standards may be too static, focused only on the market situation at the time of examination and not dealing with more dynamic threats of harm that may materialize in the future and have an impact on the level and direction of innovation. From these critiques followed suggestions as to the development of

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[183] 118th Congress, *S.3692 - Preventing the Algorithmic Facilitation of Rental Housing Cartels Act* (2024).
[184] Heather Vogell, *Rent Going Up? One Company's Algorithm Could Be Why*, PROPUBLICA (October 15 2022), https://www.propublica.org/article/yieldstar-rent-increase-realpage-rent.
[185] Mike Scarcella, *RealPage antitrust lawsuits over rent prices consolidated in Tennessee*, REUTERS (April 10 2023) https://www.reuters.com/legal/litigation/realpage-antitrust-lawsuits-over-rent-prices-consolidated-tennessee-2023-04-10/.
[186] *See* Office of Public Affairs, Justice Department Sues RealPage for Algorithmic Pricing Scheme that Harms Millions of American Renters, US DEPARTMENT OF JUSTICE (August 23 2024), https://www.justice.gov/opa/pr/justice-department-sues-realpage-algorithmic-pricing-scheme-harms-millions-american-renters.
[187] 118th Congress, *S.3686 - Preventing Algorithmic Collusion Act* (2024), https://www.congress.gov/bill/118th-congress/senate-bill/3686.
[188] SULEYMAN, *supra* note 3 at 261.

different theories of harm, the adjustment of standards of proof regarding the nature and amount of evidence required to prove allegations, and eventually the use of presumptions. Focusing on future harm and conducting prospective analysis before taking remedial action is an essential feature of merger control and other ex-ante tools. However, in the presence of scientific uncertainty and of novel threats of harm, this futurization of competition law expands in all areas of enforcement. Although the concerns prompting such approaches are new, this is not the first time the precautionary principle inspired the competition law playbook.

(a) The Threat of Economic Concentration and the Incipiency Doctrine

US law was the first regime to pioneer the introduction of precautionary approaches, and the 'incipiency doctrine' that developed following the adoption of the Clayton Act in 1914[189] reflects a high watermark of such integration. The Act complements the Sherman Act,[190] adopted two decades earlier, by prohibiting exclusive dealing and tying (Article 3) as well as mergers and acquisitions the effect of which "may be substantially to lessen competition, or to tend to create monopoly" (Article 7). The goal pursued by the Act, as explained in the House of Representatives Report accompanying the Bill, was to "arrest the creation of trusts, conspiracies, and monopolies in their incipiency and before consummation."[191]

The development of this doctrine took place in the context of aggressive merger enforcement against economic concentration and abuse of economic power in the pre-Chicago "consumer-welfare" driven antitrust era.[192] The doctrine highlighted the importance of protecting "redundant" competitors that were considered crucial for the preservation of the competitive process.[193] In the 1960s federal authorities, supported by US Supreme Court precedent, employed the doctrine to block a series of mergers that would have increased (even moderately) economic concentration.[194] The Supreme Court held in *Brown Shoe* that by

[189] 15 U.S.C. § 12-27.
[190] 15 U.S.C. § 1-2.
[191] S. Rep. No. 698, 63d Cong. 24 Sess. 1 (1914) cited by Richard Steuer, *Incipiency*, 31 LO. CONSUMER L. REV. 155, 160 (2019); 15 U.S.C. § 13 noting the motivation to avoid "little monopolies to grow into big monopolies"; Ward S. Bowman, *Contrasts in Antitrust Theory: II*, 65 COLUM. LAW REV. 417, (1965).
[192] Lina M. Khan, *The Ideological Roots of America's Market Power Problem*, 127 YALE L.J. 960 (2018); Keith N. Hylton, *Brown Shoe Versus the Horizontal Merger Guidelines*, 39 REV. INDUSTRIAL ORG. 95 (2011).
[193] Peter Carstensen & Robert H. Lande, *The Merger Incipiency Doctrine and the Importance of "Redundant" Competitors*, WIS. L. REV. 783 (2018).
[194] *See* Brown Shoe Co. v. United States, 370 U.S. 294 (1962); United States v. Philadelphia National Bank, 374 U.S. 321 (1963); United States v. Aluminium Co. of America, 377 U.S. 271 (1964); United States v. von Grocery, 384 U.S. 270 (1966).

adopting the Clayton Act, Congress was concerned "with probabilities, not certainties,"[195] while in *Philadelphia National Bank* the Supreme Court acknowledged that the incipiency doctrine "requires not merely an appraisal of the immediate impact of the merger upon competition, but a prediction of its impact upon competitive conditions in the future."[196] Regarding the formulation of the incipiency doctrine in the context of the prohibition of exclusive dealing and tying, the courts recognised the shortcomings of relying on quantitative tests[197] and instead embraced a qualitative substantiality approach focusing on the "probable effect" on competition and allowing for the consideration of factors beyond just the coverage or percentage of foreclosure.[198]

In their seminal study on the incipiency doctrine Carstensen and Lande list "at least" five formulations of the incipiency doctrine, accounting for (a) the amount of harm required to prove for a competition law violation, (b) the cumulative effect of harm because of a broader "industry trend or wave", (c) the "lower degree of probability of proof of harm" to suffice for a finding of a violation of the law, (d) the timing of harm and the need to "look further into the future for possible harm", (e) the acceptance that competition enforcement "should err on the side of overenforcement" thus signifying a different calculus as to the error costs usually considered in the framework for antitrust.[199]

As is highlighted by these different dimensions of the doctrine, the core concern for the application of the incipiency doctrine is the perceived threat of economic concentration, as an archetypical harm to competition. This was challenged by the Chicago School's more consequentialist emphasis on market outcomes as measured by effects on price and output, and the reduced emphasis on containing economic concentration as a goal of competition law both in the US and Europe.[200] This led to the relative demise of the incipiency doctrine in the enforcement policy of the US Department of Justice and Federal Trade Commission from the late 1970s until interest resurfaced in all but name in the mid-2010s with competition policy

[195] Brown Shoe Co. v. United States, 370 U.S. 294 (1962) at 323.
[196] United States v. Philadelphia National Bank, 374 U.S. 321 (1963) at 362.
[197] *See* Standard Oil Co. v. United States (Standard Stations), 377 U.S. 293 (1949).
[198] Tampa Electric Co. v. Nashville Coal Co., 365 U.S. 320, 329 (1961); *FTC v. Brown Shoe Co*., 384 U.S. 316, 322 (1966) where the US Supreme Court held that the FTC had acted well within its authority under Section 5 FTC Act by striking down an exclusive dealing arrangement between Brown Shoe and 650 franchised show outlets which required the stores to primarily purchase Brown Shoe products and restricted them from buying or selling competitors' shoes, even if the franchise network in question affected only 1% of the national shoe market, and did not violate the Clayton and the Sherman Act, the incipiency doctrine being an important explanatory factor for the Court's judgment.
[199] Carstensen & Lande, *supra* note 193 at 781.
[200] *See* Ioannis Lianos, *Some reflections on the question of the goals of EU Competition Law* in HANDBOOK ON EUROPEAN COMPETITION LAW (Ioannis Lianos & Damien Geradin eds., 2013).

aiming to contain the rise of economic concentration[201] in light of accompanying societal harm in the digital economy[202] and beyond.[203] The recent FTC and USDOJ Merger Guidelines partly embrace this perspective by taking a precautionary approach regarding mergers that involve a dominant firm acquiring a nascent competitive threat so that it doesn't grow into a significant rival leading to a reduction in its power, although the focus is not only on the rise of concentration but also on risks to potential competition and innovation.[204]

(b) The Rise of the Potential Competition Doctrine and Potential Effects

It is possible to argue that the modern expression of the 'incipiency doctrine' takes the form of protecting potential competition, an indirect reference to the importance of the competitive process without however linking the more "static" focus of preserving market structure from economic concentration as in the previous era. The idea of 'potential competition' integrates a dynamic element of behaviour (and focus on incentives) and is very much related to the consideration of the likelihood of new entry as a constraint to the pricing decisions of an incumbent. This is not to say that any traditional structural concerns highlighted in standard economic theory are absent. Indeed, entry and expansion barriers are possibly the most important element in the definition of relevant market and in the assessment of market power.[205] However, as entry barriers can be a contextual element in an investigation they can also themselves be the focus of the investigation - what is often called 'strategic' entry barriers, as opposed to 'natural', 'structural', or 'intrinsic' ones which the incumbent should not be held liable for.[206]

As remarked by Bush and Massa in their analysis of US antitrust law, the potential competition doctrine operates both as a shield and as a sword.[207] During the 1960s and 1970s,

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[201] The Council of Economic Advisers raised concerns over the increasing consolidation of a number of industrial and economic sectors during the last years of the Obama administration in *Benefits of Competition and Indicators of Market Power*, COUNCIL OF ECONOMIC ADVISERS ISSUE BRIEF (April 2016), https:// obamawhitehouse.archives.gov/ sites/ default/ files/ page/ files/ 20160414_ cea_ competition_ issue_ brief.pdf.
[202] *See* Jonathan S. Kanter, *Digital markets and 'trends towards concentration'*, 11(2) J. ANTITRUST ENFORC. 143 (2023).
[203] Richard Steuer, *Incipiency*, 31 LO. CONSUMER L. REV. 155 (2019); TIM WU, THE CURSE OF BIGNESS: ANTITRUST IN THE NEW GILDED AGE (Columbia University Press 2018).
[204] U.S. DEPARTMENT OF JUSTICE AND THE FEDERAL TRADE COMMISSION, MERGER GUIDELINES (2023), at 20.
[205] *See* JOE S. BAIN, BARRIERS TO NEW COMPETITION: THEIR CHARACTER AND CONSEQUENCES IN MANUFACTURING INDUSTRIES (Harvard University Press 1956); WILLIAM J. BAUMOL ET AL., CONTESTABLE MARKETS AND THE THEORY OF INDUSTRY STRUCTURE (Harcourt Brace Jovanovic 1982).
[206] Preston R. Fee et al., *What Is a Barrier to Entry?,* 94 AM. ECON. REV. 461 (2004); Organisation for Economic Co-operation and Development, *Barriers to Entry - DAF/ COMP(2005)42*, 24–6 (March 6 2006).
[207] Darren Bush & Salvatore Massa, *Rethinking the Potential Competition Doctrine*, WIS. L. REV. 1035 (2004).

US case law conceptualized the doctrine of potential competition "as one where a firm sitting on the sidelines of a market exerted competitive pressure on market participants because the firms that were selling in that particular market took the threat of entry into account", and this "perceived potential competition" constrained the market power of the incumbents.[208] As it is "exceptionally difficult to prove perception", the courts in subsequent case law moved away from a subjective perception to consider the situation in which firms may prospectively compete if they enter the market.[209] This led courts to examine the type of evidence necessary to show that a potential competitor is having some impact on the market. Focus was placed on the attributes of a potential competitor, market conditions and trends to determine the financial incentives to enter a particular market and the actions the alleged potential entrant had taken to enter.[210] Such tests focus on building a credible potential competition narrative, either as a defence to the finding of market power or as a sword in case there is a strategy followed to block potential entry. This allows some flexibility to engage with the temporal dimension of the competition harm and the uncertainty of the impact that such a new entrant will have on competition in the market in question.[211]

With respect to the different approaches focusing on innovation (examined in the following sub-section), the potential competition doctrine does not depart from the traditional focus of competition analysis on the strategy of constraining price to reduce the risk of future entry.[212] Applying potential competition analysis would, however, require that one of the firms is already an established supplier of the relevant good or service, which is not always the case, and some effects, for example possible delays due to regulatory requirements, cannot be captured by the tool of potential competition but may be if one assesses the competitive effect on innovation.

Potential competition can be conceived in distinct ways in EU competition law. First, excluding a potential competitor may raise concerns, particularly in contexts where the incumbent benefits from entry barriers, such as IP rights, that provide the possibility for supra-competitive pricing.[213] Second, protecting potential competition (or a potential competitor) is a default fallback option in the presence of uncertainty as to the actual effects of a specific

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[208] *Id*. at 1054.
[209] *Id*. at 1131.
[210] *Id*. at 1065.
[211] *Id*. at 1143.
[212] Robert J. Hoerner, *Innovation Markets: New Wine in Old Bottles?*, 64 ANTITRUST L. J. 49 (1995).
[213] Niamh Dunne, *The Concept of Potential Competition*, ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (May 25 2021) noting case law considering that payments to delay the entry of a competing generic drug manufacturer constitute by object restrictions of competition may provide an illustration for this operation of the potential competition concept.

conduct on competition.[214] Third, potential competition may be considered as a synonym for potential effects to competition. For instance, in order to establish under EU competition law that a practice is abusive its detrimental effect on competition must exist, although it need not necessarily be quantified and it is sufficient to prove the potential existence of such an effect capable of eliminating competitors who are at least as efficient as the dominant undertaking.[215] The CJEU case law rejects "purely hypothetical" anti-competitive effects, although it seems content with anything more than that.[216] Potential effects can be demonstrated through an economic theory of harm, based on reliable scientific evidence (e.g. an economic model) which predicts that the adoption of the particular practice will bring about negative economic effects on effective competition. However, a potential threat (risk) of harm to competition may also be assessed according to the principle of prevention and precaution, which requires action even in the presence of uncertainty as to the existence of concrete harm.

The concept of potential effects on competition is therefore broad and extends to more abstract effects of jeopardizing the competitive structure and functioning of the market and in general the public good of the competitive process.[217] The potential effects doctrine thus appears to have become an ordinary risk assessment technique that also integrates some flavour of the precautionary principle.

(c) *Theories of Harm Addressing Innovation Effects: The Emergence of Precautionary Innovation Antitrust*

Although structural elements (avoiding market concentration and the exclusion of potential competitors) remain evident in both the incipiency and potential competition doctrine, as competition authorities realign to the more prospective analysis of assessing the innovation effects of specific business conduct or market configurations, the question arises as to whether

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[214] European Commission, *Draft Guidelines on the Application of Article 102 of the Treaty on the Functioning of the European Union to abusive exclusionary conduct by dominant undertakings* at paras 6 & 73 (2024); E.ON Ruhrgas and E.ON v Commission, Case T- 360/ 09 (Court of Justice of European Union 2012) at paras 92-93 & 106; The EU courts take care to require that potential competition should not account to a purely theoretical possibility of entry into the market, this being not sufficient to demonstrate the existence of a restriction of such competition.

[215] Konkurrensverket v TeliaSonera Sverige AB, Case C-52/09, (Court of Justice of European Union 2011) at para. 64; Post Danmark A/S v Konkurrencerådet, Case C- 23/14 P (Court of Justice of European Union 2015) at para. 66.

[216] Post Danmark A/S v Konkurrencerådet, Case C- 23/14 P (Court of Justice of European Union 2015) at para. 64.

[217] *See also* Greek Council of State (ΣτΕ) 985/2023, Beer case, at para. 27 where the Greek Supreme Administrative Court in their judgement noted the link between the potential effects doctrine and the general constitutional principles of prevention and precaution.

structural elements provide a sufficient proxy for negative innovation effects, or an alternative standard would be more suitable.

To gauge innovation effects in the context of merger control, recent economic literature has advocated for the internalisation of the business stealing effect that influences the incentives of economic actors to innovate.[218] Assuming that unilateral innovation effects are closely analogous to unilateral price effects, the approach advances the logic that the higher the innovation ratio (business stealing effects of an innovation) the more likely the merged entity will scale back or cease to innovate and thus increase the "probabilistic loss of competition".[219]

This approach is inspired by arguments in favour of a more dynamic Schumpeterian perspective on competition coupled with empirical evidence of the inverted U relation between competition and innovation.[220] Federico et al. distinguish between different types of mergers involving innovation effects and examine their impact on competition in accordance with the business stealing effect criterion.[221] Consideration of the impact on competition of adjusting the uncertainty of the average probability of the successful introduction of a pipeline product, leads to the finding that a merger may be anticompetitive even if there is "low probability" that the rival will introduce the business stealing pipeline product.[222] This conclusion seems motivated by a precautionary approach in favour of innovation variety, to the extent that a decision is reached even if there is uncertainty as to the possible development of the overlapping pipeline product by the rival.[223]

(d) Error Cost Analyses in Competition Law and the Precautionary Approach

Following the identification of a market failure resulting from the exercise of market power, competition authorities traditionally employ an error cost framework in their assessment of the need to intervene or not in a specific market. There are two forms of social costs: 'substantive

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[218] Giulio Federico et al., *Antitrust and Innovation: Welcoming and Protecting Disruption,* 20(1) INNOVATION POLICY AND THE ECONOMY 125 (2020).
[219] *Id*. at 132.
[220] Philippe Aghion et al., *Competition and Innovation: An Inverted-U Relationship*, 120(2) Q. J. ECON. 701 (2005).
[221] Federico et al., *supra* note 218 at 138-145.
[222] *Id*. at 143.
[223] *See* the discussion about the entry of Activision in cloud gaming and the concerns expressed by the UK CMA that the deal could alter the future of the fast-growing cloud gaming market; Competition Markets Authority, *Anticipated acquisition by Microsoft of Activision Blizzard, Inc*., GOV.UK (April 26, 2023), https://www.gov.uk/cma-cases/microsoft-slash-activision-blizzard-merger-inquiry .

costs' or error costs, and 'procedural costs' or decision costs.[224] False positives (or type I error) occur when the decision maker finds violations although the conduct did not harm competition, while false negatives (or type II error) occur when the decision maker does not find violations although the conduct harmed competition.[225] Decision makers employ a sequential information gathering process to reduce decision costs, while of course aiming to minimize the occurrence of substantive costs (false positives and negatives).[226] The decision to acquire more information is therefore a trade-off between these two types of costs.[227]

Gal and Padilla argue that the development of AI may challenge the way different types of conduct affects market dynamics, impacting "the relative likelihood and cost of the false positive and false negative errors" and ultimately challenging "the optimal balance between false positive and false negative errors and information costs on which some current legal rules are based."[228] AI "can strengthen the consequences of exclusionary or exploitative conduct" and accordingly puts more weight on avoiding the likelihood and resultant costs of false negative errors, especially as the use of AI by competition law enforcement reduces decision costs.[229] These suggestions are compatible with an application of the precautionary principle which traditionally applies in situations where avoiding false negatives is considered more socially costly than avoiding false positives.[230] However, one may challenge the reliance on the error cost framework altogether, given the rapid development of technology and the limited knowledge of competition policy makers and authorities regarding the real impact of their decisions into the future.

In this case, we can refer to a distinct descriptive model that relies on Bayesian statistics where probabilities are beliefs, rather than classical statistics where probabilities are objective. In the Bayesian analysis, the starting point is a 'prior belief' about the state of the world, and

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[224] C.Frederick Beckner III & Steven C. Salop, *Decision Theory and Antitrust Rules*, 67 ANTITRUST L. J. 41 (1999).

[225] Jonathan B. Baker, *Taking the Error out of the 'Error Cost' Analysis: What's Wrong with Antitrust's Right*, 80(1) ANTITRUST L. J. 1 (2015); Richard A. Posner, *An Economic Approach to Legal Procedure and Judicial Administration*, 2 J. LEGAL STUD. 399 (1973); Paul L. Joskow & Alvin. K. Klevorick, *A Framework for Analyzing Predatory Pricing Policy*, 89 YALE L. J. 213 (1979); Frank H. Easterbrook, *The Limits of Antitrust*, 63 TEXAS L. REV. 1 (1984).

[226] *See* Jonathan B. Baker, *Taking the Error out of the 'Error Cost' Analysis: What's Wrong with Antitrust's Right*, 80(1) ANTITRUST L. J. 1 (2015) noting "(t)hat framework was first employed in the law and economics literature by Richard Posner during the 1970s and introduced into mainstream antitrust scholarship by Paul Joskow and Alvin Klevorick in 1979. Modern antitrust commentators often refer to Frank Easterbrook's adoption of the framework in a widely-cited article published in 1984", but the idea is older.

[227] Beckner III & Salop, *supra* note 224 at 46.

[228] Michal Gal & Jorge Padilla, *A General Framework for Analyzing the Effects of Algorithms on Optimal Competition Laws*, THEORETICAL INQUIRIES IN LAW (2024), https://ssrn.com/abstract=4883117 at 23.

[229] *Id*. at 24.

[230] Erik Persson, *What Are the Core Ideas Behind the Precautionary Principle?*, SCI. TOTAL ENVIRON. 134 (2016).

then evidence changes those beliefs so that the endpoint is a 'posterior belief'.[231] However, this is not ideal either as prior beliefs may affect the resulting posterior belief, whereas in an ideal world the evidence alone should drive the conclusion. In these more uncertain contexts relying on a precautionary principle and adjusting iteratively its use, by considering the existing knowledge about the threats of harm in devising proportional action, may offer a superior decision procedure than resorting to the error cost framework. As threats of harm may range from "deterministic certainty" to "gross uncertainty", and include "Knightian risk", "Knightian uncertainty", and "commonsense uncertainty", a specific precautionary methodology may be devised for each type of uncertainty.[232]

(e) Experimenting with Future-Gazing and "Early-Warning" Tools in Competition Law

The development of new approaches for future planning in a highly uncertain world characterised by rapid technological change, has become a prominent feature of modern strategic foresight techniques used in government[233]. These techniques include: 'horizon scanning' which helps assess future threats and serves as input for scenario development public policy processes; 'super forecasting'[234] and other forecasting tools including the scenario or the 'Delphi methods'; and 'road mapping', which associates communities of experts and

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[231] Specifically, Bayesian statisticians consider that an investigator will begin with a 'prior belief' about a given hypothesis, P(h). Evidence may then allow those beliefs to be updated to give 'posterior beliefs' describing the likelihood of the hypothesis given the evidence, P(h|e). Bayesian statisticians use Bayes Theorem to calculate their posterior beliefs using the formula $P(h|e) = P(e|h)^* P(h)/P(e)$ where P(e) denotes the probability of observing the evidence we see; P(e|h) denotes the probability of observing the evidence given the hypothesis h; and P(h) is the prior belief.

[232] RANDALL, *supra* note 18 at 185-187.

[233] *See* Effie Amanatidou et al., *On concepts and methods in horizon scanning: Lessons from initiating policy dialogues on emerging issues*, 39(2) SCI. PUBLIC POLICY 208 (2012); Food And Agriculture Organisation of the United Nations, *Horizon Scanning and Foresight – An Overview of Approaches and Possible Applications in Food Safety - Background Paper 2*, FOOD AND AGRICULTURE ORGANISATION (2014), https://openknowledge.fao.org/server/api/core/bitstreams/346e5c79-83ad-46e5-b28e-961996ba03bd/content; European Commission Directorate-General for Research and Innovation, Models of horizon scanning – How to integrate horizon scanning into European research and innovation policies, PUBLICATIONS OFFICE OF THE EUROPEAN COMMISSION (2015), https://data.europa.eu/doi/10.2777/338823; Organisation for Economic Co-operation and Development, *Back to the Future of Education: Four OECD Scenarios for Schooling - Educational Research and Innovation*, OECD PUBLISHING (2020), https://doi.org/10.1787/178ef527-en; NATIONAL ACADEMIES OF SCIENCE, ENGINEERING, AND MEDICINE, SAFEGUARDING THE BIOECONOMY (National Academies Press 2020) at Chapter 6; Government Office for Science, *The Futures Toolkit*, GOV.UK (2024), https://www.gov.uk/government/publications/futures-toolkit-for-policy-makers-and-analysts/the-futures-toolkit-html; Tom Wells & Charlie Rodgers, *Building our vision for government technology scanning*, BLOG FUTURES, FORESIGHT AND HORIZON SCANNING (July 29 2021), https://foresightprojects.blog.gov.uk/2021/07/29/building-our-vision-for-government-technology-scanning/.

[234] PHILIP E. TETLOCK & DAN GARDNER, SUPERFORECASTING: THE ART AND SCIENCE OF PREDICTION (Crown 2016).

quantitative foresight tools such as agent-based modelling and dynamic simulation models.[235] Such approaches have already been applied in the context of assessing the threats of harm to competition from AI and the digital economy, with horizon scanning reports (and accompanying "strategic" reports[236]) completed by the Data, Technology and Analytics unit (DaTA) and the Digital Markets Unit (DMU) at the UK Competition and Markets Authority.[237] The above forementioned reports on the possible threats of AI to competition provide a further illustration. Additionally, "early warning" and "red teaming" mechanisms, that test for threats to competition of technology systems, may also be voluntarily adopted by undertakings as part of their compliance efforts, with the potential to eventually standardise their use and involve independent experts for government-led audits.[238] The use of regulatory sandboxes may provide adequate ground to experiment with new business models, while at the same time engaging constructively with competition authorities to mitigate and thus contain any threats that they might engender.[239]

There is great potential to use strategic foresight methods more extensively in all areas of competition law,[240] especially in addressing new threats of harm to competition arising from evolving technologies and complex systems. It is further important to integrate these methods into a broader framework that considers the concerns of responsible and sustainable innovation. Any framework should also adopt a participatory public policy approach, in order to address threats of harm in line with the strategic interests of all stakeholders.

CONCLUSION

This study explores the challenges faced by competition law enforcement in the face of significant technological advancements in AI. The key features of the latest technology

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[235] NATIONAL ACADEMIES OF SCIENCE, ENGINEERING, AND MEDICINE, SAFEGUARDING THE BIOECONOMY 247-249 (National Academies Press 2020); Daniel Haag & Martin Kaupenjohann, *Parameters, prediction, post-normal science and the precautionary principle—a roadmap for modelling for decision-making* (2001) 144(1) ECOL. MODEL. 45.
[236] CMA, *supra* note 109.
[237] Competition Markets Authority (CMA), *Algorithms: How they can reduce competition and harm consumers*, GOV.UK (January 2021), https://www.gov.uk/government/publications/algorithms-how-they-can-reduce-competition-and-harm-consumers/algorithms-how-they-can-reduce-competition-and-harm-consumers; Competition Markets Authority (CMA), *Horizon Scanning; Trends in Digital Markets: a CMA horizon scanning report,* GOV.UK (2023), https://www.gov.uk/government/publications/trends-in-digital-markets-a-cma-horizon-scanning-report.
[238] SULEYMAN, *supra* note 3 at 246.
[239] *See* Ioannis Lianos, *Reorienting Competition Law*, 10(1) J. ANTITRUST ENFORC. 1 (2022).
[240] Klaudia Majcher & Viktoria H.S.E. Robertson, *Strategic Foresight and EU Competition Law* (January 30 2024) https://ssrn.com/abstract=4710206.

"wave"[241] are (a) the "asymmetries" to which they give rise, (b) "hyper-evolution" and concentration of global economic control (c) "omni-use" of General Purpose Technologies (GPTs), and (d) "autonomy" that ceases the need for humans to be "in the loop". These new "synthetic worlds" challenge the usual contours of our thought and epistemic toolkit and raise new threats of harm.

The underlying foundation of this important technological and social transformation is the emergence of complex systems[242], characterized by continuous interaction of multiple (autonomous) agents active in various economic and social spheres. This makes predicting the pattern of evolution of these adaptive systems particularly challenging and calls for more agile regulatory decision-making processes and methodologies.[243] Higher levels of uncertainty require a policy design that is aware of the gaps in our knowledge base and remains open to the existence of multiple potential innovation trajectories and different "synthetic futures".

This study explores the hypothesis that the legal concept developed to deal with the unpredictable, the precautionary principle, may guide the action of competition authorities, focusing on AI and other technologies of the "incoming wave". It discusses how competition agencies and courts currently deal with threats to competition from corporate strategies reliant on new AI capabilities and the increased use of algorithms, as well as the limitations of the Ordinary Risk Management approach. In light of the shortcomings of alternative approaches, this study explores how the precautionary principle might be a more accurate and normatively appropriate option for regulating threats in complex (and "synthetic") systems. Concerns about the precautionary principle are also addressed and a more inclusive interaction between the precautionary principle and innovation, within the framework of responsible and sustainable innovation, is proposed. Finally, this study examines how the precautionary principle can be integrated into competition law doctrines and institutions, allowing authorities to more comprehensively limit new threats of harm caused by this technological wave.

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[241] SULEYMAN, *supra* note 3 at 114.
[242] GIOVANNI DOSI, THE FOUNDATIONS OF COMPLEX EVOLVING ECONOMIES 11 (Oxford University Press 2023).
[243] GRAHAM ROOM, COMPLEXITY, INSTITUTIONS AND PUBLIC POLICY: AGILE DECISION-MAKING IN A TURBULENT WORLD (Edward Elgar 2011).